Automi, Linguaggi e Traduttori. 10 July 2009.

Precision and clarity are important. The PARSER exercise is compulsory. Use comments to document your program of the PARSER exercise. Motivate your constructions and answers.

• PARSER [5]. Write a C++ or Java program whose time complexity is at most $O(n)$, for testing whether or not a given word in $\{a,b\}^*$ of length n (>0) is generated by the grammar with axiom S and the following productions:

$S \to A\,S \mid a \qquad\qquad A \to S\,A \mid b$

• REASONING [2]. Show that for every word w in $(a+b)^*$ with an even number of a's we have that $A \to^+ w$ where A is the axiom of a grammar with the following productions:

$A \to A\,A \;\mid\; a\,A\,a \;\mid\; A\,b \;\mid\; \varepsilon$

Hint: Show by complete induction on the number of b's in the word w that we can generate from A every word w in the set $\{w \mid w \in (a+b)^* \text{ and } w \text{ has an even number of } a\text{'s}\}$.

• CONTEXT-FREE LANGUAGES [3]. Construct a pushdown automaton which recognizes *by final state* the language generated by the grammar with axiom S and the following productions:

$S \to S\;S \mid a\;S\;b \mid \varepsilon$

Show that no deterministic pushdown automaton exists that can recognize that language *by empty stack*.

• LALR [3]. Construct an $LALR(1)$ parser, if any, for the context-free grammar G with axiom S and the following productions (do not modify the given grammar before constructing the $LALR(1)$ parser): $S \to a\,A \mid b\,B$

$A \to \varepsilon \mid c\,A\,d \qquad\qquad B \to \varepsilon$

• LANGUAGES [3]. Prove that the language $\{a,b\}^* - \{a^i b^i \mid i \geq 0\}$ is a context-free language and it is *not* regular.

• DECIDABILITY [3]. Show that the intersection of two semidecidable languages subsets of $\{a,b\}^*$, is a semidecidable language.

• CORRECTNESS [3]. Let x^n be defined as follows:

if $n=0$ **then** 1 **else if** $odd(n)$ **then** $x \times (x^{n-1})$ **else** $(x^{n/2}) \times (x^{n/2})$.

Show the total correctness of the following program (I is the invariant assertion of the loop):

$\{n \geq 0\}$
$k := n;\;\; y := 1;\;\; z := x;$
$I \equiv \{y \times z^k = x^n \;\wedge\; k \geq 0\}$
while $k \neq 0$ **do** **if** $odd(k)$ **then begin** $k := k-1;\;\; y := y \times z;$ **end**; $k := k/2;\;\; z := z \times z;$
od
$\{y = x^n\}$

Nota. Tra parentesi quadre sono indicati i punti per ogni esercizio. Le due prove in itinere valgono, di norma, 4+4 punti. Per la prova orale, si presenti: (i) il programma, fatto da solo/a, dell'esercizio PARSER con alcune prove di esecuzione, (ii) un elaborato con la soluzione degli altri esercizi fatti da solo/a e (iii) si venga, se possibile, con un computer portatile ove siano istallati e pronti per l'esecuzione i programmi relativi alle due prove in itinere.

Automi, Linguaggi e Traduttori. 21 July 2009.

Precision and clarity are important. The PARSER exercise is compulsory. Use comments to document your program of the PARSER exercise. Motivate your constructions and answers.

• PARSER [5]. Write a C++ or Java program whose time complexity is at most $O(n)$, for testing whether or not a given word in $\{a,b\}^*$ of length n (>0) is generated by the grammar with axiom S and the following productions:

$S \to A\,S \;\mid\; a \qquad\qquad A \to S\,A \;\mid\; b$

Hint (suggerimento): Find the regular expression which denotes the regular language generated by the given context-free grammar.

• REASONING [2]. Show that for every word w in $(a+b)^*$ with an even number of a's, we have that $A \to^+ w$ where A is the axiom of a grammar with the following productions:

$A \to A\,A \;\mid\; a\,A\,a \;\mid\; A\,b \;\mid\; \varepsilon$

Note: You should *not* show the obvious fact that every word generated by A has an even number of a's. Instead, you should show that every word in $(a+b)^*$ with an even number of a's can be generated by A.

Hint: Show by complete induction on the number of b's in the word w that we can generate from A every word w in the set $\{w \mid w \in (a+b)^* \text{ and } w \text{ has an even number of } a\text{'s}\}$.

• CONTEXT-FREE LANGUAGES [3]. Construct a pushdown automaton which recognizes *by final state* the language generated by the grammar with axiom S and the following productions:

$S \to S\;S \mid a\;S\;b \mid \varepsilon$

Show that no deterministic pushdown automaton exists that can recognize that language *by empty stack*.

• LALR [3]. Construct an $LALR(1)$ parser, if any, for the context-free grammar G with axiom S and the following productions (do not modify the given grammar before constructing the $LALR(1)$ parser): $S \to A\,A$

$A \to a\,A \qquad\qquad A \to a$

• LANGUAGES [3]. Prove that: (1) the language $\{a,b\}^* - \{a^i b^i \mid i \geq 0\}$ is a context-free language and (2) it is *not* regular.
• DECIDABILITY [3]. Show that given two semidecidable languages $L1 \subseteq \{a,b\}^*$ and $L2 \subseteq \{a,b\}^*$, the language $(L1 \cup L2) \cap \{a^i b^i \mid i \geq 0\}$ is a semidecidable language.
• CORRECTNESS [3].
Show the total correctness of the following program (I is the invariant assertion of the loop):

$\{n \geq 0\}$
$k := n;\ \ y := 1;\ \ z := x;$
$I \equiv \{y \times z^k = x^n \ \wedge\ k \geq 0\}$
while $k \neq 0$ **do** **if** $odd(k)$ **then begin** $k := k-1;\ \ y := y \times z;$ **end**; $k := k/2;\ \ z := z \times z;$
od
$\{y = x^n\}$

Nota. Tra parentesi quadre sono indicati i punti per ogni esercizio. Le due prove in itinere valgono, di norma, 4+4 punti. Per la prova orale, si presenti: (i) il programma, fatto da solo/a, dell'esercizio PARSER con alcune prove di esecuzione, (ii) un elaborato con la soluzione degli altri esercizi fatti da solo/a e (iii) si venga, se possibile, con un computer portatile ove siano istallati e pronti per l'esecuzione i programmi relativi alle due prove in itinere.

Automi, Linguaggi e Traduttori. 15 February 2010.

Precision and clarity are important. The PARSER exercise is compulsory. Use comments to document the program of the PARSER exercise. Motivate your constructions and answers.

• PARSER [5]. Write a C++ or Java program whose time complexity is at most $O(n)$, for testing whether or not a given word in $\{a,b\}^*$ of length n (> 0) is generated by the grammar with axiom S and the following productions:
$S \rightarrow b \mid A\,A \qquad A \rightarrow a\,A \mid A\,b\,b \mid \varepsilon$
and find the regular expression which denotes the regular language generated by the given context-free grammar.

• REASONING [4]. Show that for every word w in $(a+b)^*$ with an even number of a's, we have that $A \rightarrow^+ w$ where A is the axiom of a grammar with the following productions:
$A \rightarrow A\,A \ \mid\ a\,A\,A\,a \ \mid\ A\,b \ \mid\ \varepsilon$

• REASONING [4]. Show that the following two context-free grammars $G1$ and $G2$ generate the same language:
$G1$:
$S \rightarrow \varepsilon \ \mid\ a\,B \ \mid\ b\,A \qquad B \rightarrow b\,S \ \mid\ a\,B\,B \qquad A \rightarrow a\,S \ \mid\ b\,A\,A$
$G2$:
$S \rightarrow \varepsilon \ \mid\ a\,S\,b \ \mid\ b\,S\,a \ \mid\ S\,S$
Show also that all the words generated by the grammar $G1$ have even length.

• CONTEXT-FREE LANGUAGES [3]. Construct a pushdown automaton that recognizes *by final state* the language L generated by the grammar with axiom S and the following productions:
$S \rightarrow S\ S \ \mid\ a\ S\ b \ \mid\ \varepsilon$

• LALR [3]. Construct an $LALR(1)$ parser, if any, for the context-free grammar G with axiom S and the following productions (do not modify the given grammar before constructing the parsing table of the $LR(1)$ parser):
$S \rightarrow A\,S \qquad S \rightarrow \varepsilon \qquad A \rightarrow a\,A \qquad A \rightarrow b$

• DECIDABILITY [3]. Show that given two semidecidable languages $L1, L2 \subseteq \{a,b\}^*$, the language $(L1 \cap L2) \cup \{a^h\, b^k\, c^k \mid h,k \geq 0\}$ is a semidecidable language.

• CORRECTNESS [4]. Let N be the set of natural numbers.
Let $half \in N \rightarrow N$ be the function defined by the following equations:

$$half(0) = 0 \qquad half(1) = 0 \qquad half(n+2) = half(n)+1$$

Let $f \in N \rightarrow N$ be the function defined by the following equations:

$$f(0) = 0 \qquad f(1) = 1 \qquad f(n+2) = 2 \times f(n)$$

Show that the following program:

$\{K \geq 0\}$
$k := K;$
if $even(k)$ **then** $res := 0$ **else** $res := 1$;
while $k > 1$ **do** $res := 2 \times res;\ \ k := k-2$ **od**
$\{res = f(K)\}$

is partially correct w.r.t. the initial assertion $\{K \geq 0\}$ and the final assertion $\{res = f(K)\}$ and it terminates. The invariant of the loop is: $\{k \geq 0 \ \wedge\ 2^{\,half(k)} \times res = f(K)\}$

Nota. Tra parentesi quadre sono indicati i punti per ogni esercizio. Le due prove in itinere valgono, di norma, 4+4 punti. Per la prova orale, si presenti il programma, fatto da solo/a, dell'esercizio PARSER con alcune prove di esecuzione.

Automi, Linguaggi e Traduttori. 16 February 2010.

Precision and clarity are important. The PARSER exercise is compulsory. Use comments to document the program of the PARSER exercise. Motivate your constructions and answers.

• PARSER [5]. Write a C++ or Java program whose time complexity is at most $O(n)$, for testing whether or not a given word in $\{a, b\}^*$ of length n (> 0) is generated by the grammar with axiom S and the following productions:

$S \to b \mid A\,S \mid A \qquad A \to a\,b\,A \mid A\,b \mid \varepsilon$

• REASONING [3]. Prove that there is no Turing Machine A such that: (i) for every natural number n, the Turing Machine A given in input n, returns in output the code of a Turing Machine which terminates for all inputs, and (ii) for every Turing Machine M which terminates for all inputs, there exists a natural number m such that the Turing Machine A given in input m, returns in output the code of the Turing Machine M.

• CONTEXT-FREE LANGUAGES [2]. Show that the following grammar is not an $LL(1)$ grammar:

$S \to a\ S\ b \quad | \quad a\ S\ c \quad | \quad d$

• LR [2]. Construct an $LR(1)$ parser, if there exists one, for the context-free grammar G with axiom S and the following productions: $S \to a\,S\,b \mid \varepsilon$

• LANGUAGES [3]. Prove that the intersection of the context-free language $\{a^i b^i \mid i \geq 0\}$ and any regular language subset of $(a + b)^*$ is a context-free language.

• DECIDABILITY [4]. Let L be a language recognized by a Turing machine which terminates for all inputs. Show that the set $(\Sigma^* - \{a^i b^i c^i \mid i \geq 1\}) \cup L$ is a recursive set.

• CORRECTNESS [5]. Let $N!$ denote the factorial of the natural number N. Show that the following program:

$\{N \geq 0\}$

$n := N;\ \ res := 1;$

while $n > 0$ **do** $res := res \times n;\ \ n := n - 1$ **od**

$\{res = N!\}$

is totally correct (i.e., it is partially correct and it terminates).

Nota. Tra parentesi quadre sono indicati i punti per ogni esercizio. Le due prove in itinere valgono, di norma, 3+3 punti. Per la prova orale, si presenti: (i) il programma, fatto da solo/a, dell'esercizio PARSER con alcune prove di esecuzione, (ii) un elaborato con la soluzione degli altri esercizi fatti da solo/a e (iii) si venga, se possibile, con un computer portatile ove siano istallati e pronti per l'esecuzione i programmi relativi alle due prove in itinere.

Automi, Linguaggi e Traduttori. 24 February 2010.

Precision and clarity are important. The PARSER exercise is compulsory. Use comments to document the program of the PARSER exercise. Motivate your constructions and answers.

• PARSER [5]. Write a C++ or Java program whose time complexity is at most $O(n)$, for testing whether or not a given word in $\{a, b\}^*$ of length n (> 0) is generated by the grammar with axiom S and the following productions:

$S \to A\,S\,A \mid A \qquad\qquad A \to a\,A\,a \mid A\,b \mid \varepsilon$

• REASONING [3]. Show that the language generated by the grammar with axiom S and the following productions:

$S \to b \mid A\,S \mid A \qquad\qquad A \to a\,b\,A \mid A\,b \mid \varepsilon$

is equal to the language generated by the grammar with axiom A and the following productions:

$A \to a\,b\,A \mid A\,b \mid b\,A \mid \varepsilon$

• CONTEXT-FREE LANGUAGES [2]. Write an ambiguous grammar which generates the following language: $\{a^n b^m \mid 0 \leq m < n\}$. Write a non-ambiguous grammar for that same language.

• LR [2]. Construct an $LR(1)$ parser, if any, for the context-free grammar G with axiom E and the following productions:

$E \to E + T \ \mid\ T \qquad\qquad T \to T \times a \ \mid\ a$

• LANGUAGES [4]. Prove that $a(ba)^* = (ab)^*a$ and $(a^*b)^*a \neq a(ba^*)^*$.

• DECIDABILITY [3]. (D1) Write in pseudocode an algorithm, if there exists one, that: (i) terminates for all inputs, and (ii) given a context-free grammar G, decides whether or not G is ambiguous.

(D2) Write in pseudocode an algorithm, if there exists one, that: (i) terminates for all inputs, and (ii) given a context-free grammar G, decides whether or not G generates a deterministic context-free language.

(D3) Write in pseudocode an algorithm, if there exists one, that: (i) terminates for all inputs, and (ii) given a context-free grammar G, decides whether or not G is a regular grammar.

• CORRECTNESS [5]. Let $N!$ denote the factorial of the natural number N. Show that the following program:

$\{N \geq 0\}$

if $N = 0$ **then** $res := 1$ **else**
begin
$n := 1;\ res := 1;$
while $n \leq N$ **do** $res := res \times n;\quad n := n+1;$ **od**
end

$\{res = N!\}$

is totally correct (i.e., it is partially correct and it terminates).

Nota. Tra parentesi quadre sono indicati i punti per ogni esercizio. Le due prove in itinere valgono, di norma, 3+3 punti. Per la prova orale, si presenti: (i) il programma, fatto da solo/a, dell'esercizio PARSER con alcune prove di esecuzione, (ii) un elaborato con la soluzione degli altri esercizi fatti da solo/a e (iii) si venga, se possibile, con un computer portatile ove siano istallati e pronti per l'esecuzione i programmi relativi alle due prove in itinere.

Automi, Linguaggi e Traduttori. 13 July 2010.

Precision and clarity are important. The PARSER exercise is compulsory. Use comments to document the program of the PARSER exercise. Motivate your constructions and answers.

• PARSER [5]. Write a C++ or Java program whose time complexity is at most $O(n)$, for testing whether or not a given word in $\{a, b\}^*$ of length n (≥ 0) is generated by the grammar with axiom S and the following productions:

$S \to a\,B\,S\,B\,a \mid \varepsilon \qquad B \to b\,B\,b \mid \varepsilon$

• REASONING [2]. Consider the language $L1$ generated by the grammar with axiom S_1 and the following productions:

$S_1 \to a\,B\,S_1\,B\,a \mid \varepsilon \qquad B \to b\,B\,b \mid \varepsilon$

Consider the language $L2$ generated by the grammar with axiom S_2 and the following productions:

$S_2 \to a\,B\,S_2\,B\,a \mid a\,B\,B\,a \qquad B \to b\,B\,b \mid \varepsilon$

Show that $L1 = L2 \cup \{\varepsilon\}$.

• CONTEXT-FREE LANGUAGES [2]. Construct a pushdown automaton which recognizes *by final state* the language generated by the grammar with axiom S and the following productions:

$S \to S\ S\ S \quad | \quad a\ S\ b \quad | \quad \varepsilon$

• GREIBACH NORMAL FORM [3]. Give a grammar in Greibach normal form which generates the language

$\{0^i 1^k a 2^i \mid i \geq 1 \text{ and } k \geq 1\} \ \cup\ \{0^i 1^k b 2^k \mid i \geq 1 \text{ and } k \geq 1\}$

Show that this language is a deterministic context-free language.

• LR [3]. Construct an $LR(1)$ parser, if any, for the context-free grammar G with axiom S and the following productions (do not modify the given grammar before constructing the parsing table of the $LR(1)$ parser):

$S \to A\,S \qquad S \to \varepsilon \qquad A \to a\,A \qquad A \to b$

• LANGUAGES [3]. Prove that the intersection of the context-free language $\{a^i b^i \mid i \geq 0\}$ and any regular language subset of $(a + b + c)^*$ is a context-free language.

• DECIDABILITY [3]. Show that if the language $L \subseteq \{a, b\}^*$ is semidecidable and $\{a, b\}^* - L$ is semidecidable, then $L \cup \{a^h\, b^k \mid h, k \geq 0\}^*$ is a decidable language.

• CORRECTNESS [3].Show that for any $a, b \in N$, for any function $c \in N \to N$, for any function $f \in N \to N$ defined by the following equations: $\quad f(0) = a \qquad f(1) = b \qquad f(n+2) = c(f(n))$

we have that the following program:

$\{K \geq 0\}$

$k := K;$
if $even(k)$ **then** $res := a$ **else** $res := b\,;$
while $k > 1$ **do** $res := c(res);\ \ k := k-2$ **od**

$\{res = f(K)\}$

is partially correct w.r.t. the given input and output assertions and it terminates for all $K \geq 0$.
Hint. Find the invariant assertion of the loop.

Nota. Tra parentesi quadre sono indicati i punti per ogni esercizio. Le due prove in itinere valgono, di norma, 3+3 punti. Per la prova orale, si presenti: (i) il programma, fatto da solo/a, dell'esercizio PARSER con alcune prove di esecuzione, (ii) un elaborato con la soluzione degli altri esercizi fatti da solo/a e (iii) si venga, se possibile, con un computer portatile ove siano istallati e pronti per l'esecuzione i programmi relativi alle due prove in itinere.

Automi, Linguaggi e Traduttori. 8 September 2010.

Precision and clarity are important. The PARSER exercise is compulsory. Use comments to document your program of the PARSER exercise. Motivate your constructions and answers.

• PARSER [5]. Write a C++ or Java program whose time complexity is at most $O(n)$, for testing whether or not a word in $\{a, b\}^*$ of length n (≥ 0) is generated by the grammar with axiom S and the following productions:

$S \to a \mid S\,A\,A \mid \varepsilon \qquad A \to a\,A \mid A\,a\,b \mid A\,b\,a \mid \epsilon$

• REGULAR LANGUAGE [3]. Show that for all $k \geq 1$, every context-free grammar $\langle\{a, b\}, V_N, P, S\rangle$ such that every sentential form it generates has at most length k^3, generates a regular language.

• REGULAR EXPRESSIONS [3]. Show that the regular expressions $a(ba)^*$ and $(ab)^*a$ denote the same subsets of $\{a, b\}^*$.

• CONTEXT-FREE [3]. Show that the language $\{a, b\}^* - \{a^i b^i \mid i \geq 0\}$ is context-free.

• GREIBACH [2]. Compute the Greibach normal form of the following grammar:

$S \to S\ A \mid a \qquad A \to S \mid A\ S \mid a \mid \varepsilon$

• LALR [3]. Construct an $LALR(1)$ parser, if any, for the context-free grammar G with axiom S and the following productions:

$S \to B\,B\,a \qquad B \to B\,b \ \mid\ c$

• DECIDABILITY [2]. Show that the set of all pairs ⟨Java program P, n⟩ such that P does not halt for the input n is not semidecidable.

• CORRECTNESS [3]. Show the total correctness of the following program which takes in input the two integer values X and Y and computes their product.

$\{X > 0 \ \wedge\ Y > 0\}$
$x := X;\ \ y := Y;\ \ p := 0;$
while $x > 1$ **do** **if** $even(x)$ **then begin** $x := x/2;\ \ y := 2\,y;$ **end**;
else begin $x := x - 1;\ \ p := p + y;$ **end**;
od
$p := p + y;$
$\{p = X\,Y\}$

Nota. Tra parentesi quadre sono indicati i punti per ogni esercizio. Le due prove in itinere valgono, di norma, 3+3 punti. Per la prova orale, si presenti: (i) il programma, *fatto da solo/a*, dell'Esercizio del PARSER con alcune prove di esecuzione, (ii) un elaborato con la soluzione degli altri esercizi *fatto da solo/a* e (iii) si venga, se possibile, con un computer portatile ove siano istallati e pronti per l'esecuzione i programmi relativi alle due prove in itinere.

Automi, Linguaggi e Traduttori. 5 July 2011.

Precision and clarity are important. The PARSER exercise is compulsory. Use comments to document your program of the PARSER exercise. Motivate your constructions and answers.

• PARSER [6]. Write a C++ or Java program whose time complexity is at most $O(n)$, for testing whether or not a word in $\{a, b\}^*$ of length n (≥ 0) is generated by the grammar with axiom S and the following productions:

$S \to A\,S\,A \mid a \qquad A \to a\,A\,a \mid A\,b \mid \varepsilon$

• REASONING [2]. Show that for every word w in $(a + b)^*$ with an even number of a's, we have that $A \to^+ w$ where A is the axiom of a grammar with the following productions:

$A \to A\,A \ \mid\ a\,A\,A\,a \ \mid\ A\,b \ \mid\ \varepsilon$

Hint: Show by complete induction on the number of b's in the word w that A can generate every word w in the set $\{w \mid w \in (a + b)^*$ and w has an even number of a's$\}$.

• LANGUAGES [2]. Prove that the context-free language $\{a^i b^i \mid i \geq 0\}$ is a deterministic context-free language.

• GREIBACH [2]. Compute the Greibach normal form of the following grammar:

$S \to A\,S \ \mid\ a \qquad A \to a\,A \ \mid\ A\,a\,b \ \mid\ \varepsilon$

• LALR [3]. Construct an $LALR(1)$ parser, if any, for the context-free grammar G with axiom S and the following productions: $S \to B\ B \qquad B \to b\ B \mid a$

• DECIDABILITY [3]. Show that it is undecidable whether or not the intersection of a regular language with a context-sensitive language is the empty language. (Recall that the emptiness problem of a context-sensitive language is undecidable.)

• CORRECTNESS [4]. Prove the total correctness of the following program:

$\{N \geq 0\}$
$n := N;$
if $even(n)$ **then** $res := a$ **else** $res := b$;
$I \equiv \{n \geq 0 \ \wedge \ c^{half(n)}(res) = h(N)\}$
while $n > 1$ **do begin** $res := c(res);\ n := n-2$ **end**
$\{res = h(N)\}$

where $h(n)$ for all $n \geq 0$ is defined as follows:

$h(0) = a \qquad h(1) = b \qquad h(n+2) = c(h(n))$

I is the invariant. The function *half* is defined as follows:

$half(0) = 0 \qquad half(1) = 0 \qquad half(n+2) = half(n)+1$

Nota. Tra parentesi quadre sono indicati i punti per ogni esercizio. Le due prove in itinere valgono, di norma, 3+3 punti. Per la prova orale, si presenti: (i) il programma, *fatto da solo/a*, dell'Esercizio del PARSER con alcune prove di esecuzione, (ii) un elaborato con la soluzione degli altri esercizi *fatto da solo/a* e (iii) si venga, se possibile, con un computer portatile ove siano istallati e pronti per l'esecuzione i programmi relativi alle due prove in itinere.

Automi, Linguaggi e Traduttori. 8 September 2011.

Precision and clarity are important. The PARSER exercise is compulsory. Use comments to document your program of the PARSER exercise. Motivate your constructions and answers.

• PARSER [6]. Write a C++ or Java program whose time complexity is at most $O(n)$, for testing whether or not a word in $\{a, b\}^*$ of length n (≥ 0) is generated by the grammar with axiom S and the following productions:

$S \rightarrow S\,A \mid a \qquad A \rightarrow a\,A\,a \mid b\,A \mid \varepsilon$

• REASONING [2]. Show that for every word w in $(a + b)^*$ with an even number of a's, we have that $A \rightarrow^+ w$ where A is the axiom of a grammar with the following productions:

$A \rightarrow A\,A \ \mid \ a\,A\,a \ \mid \ b\,A \ \mid \ \varepsilon$

• LANGUAGES [3]. (i) Prove that the context-free language $\{a, b, c\}^* - \{a^i b^i \mid i \geq 0\}$ is a deterministic context-free language.
(ii) Find a language $L \subseteq \{a, b\}^*$ which is not regular such that L^* is regular.

• GREIBACH [2]. Compute the Greibach normal form of the following grammar:

$S \rightarrow A\,S \ \mid \ b \mid \ \varepsilon \qquad A \rightarrow S\,A \ \mid \ b$

• LALR [3]. Construct an $LALR(1)$ parser, if any, for the context-free grammar G with axiom S and the following productions: $S \rightarrow A\ A\ b \qquad A \rightarrow A\ b \mid a$

• DECIDABILITY [3]. Show that from the undecidability of the problem of establishing whether or not the intersection of two context-free languages is a context-free language does not follow the undecidability of the problem of establishing whether or not the intersection of a deterministic context-free language and a context-free language is a context-free language.

• CORRECTNESS [3]. Prove the total correctness of the following program:

$\{N \geq 0\}$
$n := N; \quad res := a;$
while $n > 0$ **do begin** $res := c(res);\ n := n-1$ **end**
$\{res = h(N)\}$

where $h(n)$ for all $n \geq 0$ is defined as follows:

$h(0) = a \qquad h(n+1) = c(h(n))$

Nota. Tra parentesi quadre sono indicati i punti per ogni esercizio. Le due prove in itinere valgono, di norma, 3+3 punti. Per la prova orale, si presenti: (i) il programma, *fatto da solo/a*, dell'Esercizio del PARSER con alcune prove di esecuzione, (ii) un elaborato con la soluzione degli altri esercizi *fatto da solo/a* e (iii) si venga, se possibile, con un computer portatile ove siano istallati e pronti per l'esecuzione i programmi relativi alle due prove in itinere.
