Introduction to Model Checking (VO) WS 2009/2010 LVA 703503

First name: ____________________

Last name: ____________________

Matriculation number: ____________________

- Please answer all exercises in a readable and precise way.
- Please cross out solution attempts which are replaced by another solution.
- Please do not remove the staples of the exam.
- Cheating is not allowed. Everyone who is caught will fail the exam.

Exercise	Maximal points	Points
1	22	
2	21	
3	21	
4	6	
Σ	70	
Grade		

Exercise 1 (11 + 11 points)

Consider the following properties over $AP = \{s, t\}$ or $\Sigma = 2^{AP}$.

- P_1: There are infinitely many s's
- P_2: The input is of the form $(\{s\}\{s\}\{s, t\})^\omega$
- P_3: If P_1 holds then P_2 holds.

Specify each of the properties P_i

(i) as LTL formula φ_i

(ii) as NBA $\mathcal{A}_i$

Exercise 2 (21 points)

Consider the following nanoPromela statement.

```
do
  :: x=1  => if :: y=2  => c ! 3
               :: y=4  => skip
             fi ;
             d ? z
od
```

Construct the program graph for this statement. For the whole statement, additionally derive all transitions formally using the inference rules.

You may use abbreviations like "`do ... od`", "`if ... fi`", ...

Exercise 3 (7 + 14 points)

Consider the following formula:

$$\varphi = (\mathsf{a}\,\mathsf{U}\,\mathsf{b})\,\mathsf{U}\,(\mathsf{X}\,\mathsf{a})$$

(i) Fill in all values of the φ-expansion for the given input word that can uniquely be determined where … may be arbitrary.

a	0	1	0	0	1	0	0	0	0	…
b	0	1	1	1	0	1	0	1	1	…
X a										
a U b										
φ										

(ii) Construct the automaton for φ.

$\mathcal{A}_\varphi = (\{q_0\} \uplus 2^5, 2^2, q_0, \delta, F_1, F_2)$ where the Fischer Ladner closure is $cl(\varphi) = \mathsf{a}, \mathsf{b}, \underbrace{\mathsf{X}\,\mathsf{a}}_{\varphi_3}, \underbrace{\mathsf{a}\,\mathsf{U}\,\mathsf{b}}_{\varphi_4}, \varphi$

- $(c_1, \ldots, c_5)^T \in \delta(q_0, (d_1, d_2)^T)$ iff

- $(c_1, \ldots, c_5)^T \in \delta((b_1, \ldots, b_5)^T, (d_1, d_2)^T)$ iff

- $F_1 = \{(b_1, \ldots, b_5)^T \mid$

  $F_2 = \{(b_1, \ldots, b_5)^T \mid$

Explicitly list all transitions leading to state $q = (1, 0, 0, 1, 1)^T$.

Exercise 4 (6 points)

Each correct answer is worth 2 points. For each wrong answer 1 point is subtracted. It is not possible to get negative points from this exercise.

	Yes	No
LTL model checking is PSPACE complete.		
Consider restricted nanoPromela programs which may have at most 2 boolean variables (and no other variables). Then the size of the resulting transition system is polynomial in the size of the program.		
Satisfiablity of LTL-formulas is decidable.		