

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	18	
2	17	
3	26	
4	9	
Σ	70	
Grade		

Exercise 1 (10 + 8 points)

(i) Construct a NBA or GNBA for the following language over $\Sigma = \{A, B, C\}$:

$\{w \in \Sigma^\omega \mid \text{if } w \text{ contains infinitely many } A\text{'s then between any two successive } B\text{'s there is at least one } C\}$

(ii) Construct an LTL formula for the following property over $AP = \{a, b, c, d\}$:

If there are only finitely many **a**'s then there is never a **b** strictly between a **c** and a **d**.

For example, the word $\{a\} \{b\} \{a\} \{c\} \{a, b\} \{c\} \{a, d\} \emptyset^\omega$ does not satisfy the property as the second occurrence of the **b** is strictly between the first **c** and the **d**.

Exercise 2 (17 points)

Consider the following nanoPromela statement.

```
do
  :: true => c ? x ;
    if :: x = 'help' => d ! 'raise hand'
      :: x = 'solved' => d ! 'well'; d ! 'done';
    fi ;
  d ! 'time is over'
od
```

Construct the program graph for this statement. For the first transition this also has to be done formally. You may use abbreviations like “do ... od”, “if ... fi”, “rh”, “tio”, ...

Exercise 3 (6 + 20 points)

Consider the following formula:

$$\varphi = \neg(\text{true} \cup (\neg(\text{true} \cup (\text{req} \wedge \text{X}(\text{true} \cup \text{resp}))))))$$

The following exercises can be done independently!

- (i) Construct a simplified formula ψ with $\varphi \equiv \psi$ by using **F** and **G** instead of **U**. Then try to formulate the meaning of ψ in words (German or English).

- (ii) Construct the automaton for φ using the improved translation.

$\mathcal{A}_\varphi = (\{q_0\} \uplus 2^6, 2^2, q_0, \delta, F_1, F_2, F_3)$ where

- The reduced Fischer Ladner closure is

$$cl'(\varphi) = \text{req}, \text{resp},$$

- $(c_1, \dots, c_6)^T \in \delta(q_0, (d_1, d_2)^T)$ iff

- $(c_1, \dots, c_6)^T \in \delta((b_1, \dots, b_6)^T, (d_1, d_2)^T)$ iff

- $F_1 = \{(b_1, \dots, b_6)^T \mid$

$$F_2 = \{(b_1, \dots, b_6)^T \mid$$

$$F_3 = \{(b_1, \dots, b_6)^T \mid$$

Compute the number of direct successor states of state $(1, 0, 0, 0, 1, 0)^T$.

Exercise 4 (9 points)

Each correct answer is worth 3 points. A wrong answer results in zero points (for that question, not for the whole exercise). Giving no answer is worth 1 point.

	Yes	No
$F(a \cup b) \wedge G \neg a$ is satisfiable.		
If \mathcal{A}_1 has n_1 states and \mathcal{A}_2 has n_2 states then $\mathcal{A}_{\mathcal{A}_1 \cap \mathcal{A}_2}$ has $n_1 + n_2$ states.		
As LTL model checking is in PSPACE, for every LTL formula φ of size n there is a corresponding NBA for φ which has polynomial size in n .		