## Important Information for the Exam Review:

- Grading *strictly* follows the correction scheme (see below).
- If you have complaints about your correction, be sure to refer to the correction scheme below.
- We reserve the right to lower your score when reassessing your solutions.
- Based on our data from other lectures, it is not advantageous to submit a multitude of complaints "just in case." Please refrain from doing so as it causes us a lot of work.
- The purpose of the review is to rectify errors in the correction. We do not answer questions. If you have questions about the solution to a problem, please ask them on Zulip.

The following types of complaints will be ignored without comment from us:

- "Based on the model solution, my idea was heading in the right direction, so I should get at least 1 point." – We strictly adhere to the correction scheme; if no points are allocated for the idea, none will be awarded.
- "I'm only one point away from passing; can't you evaluate my exam a bit more generously?" – Unfortunately, a line must be drawn somewhere.
- "The correction scheme is inappropriate; I had almost everything correct and still got no points. Please adjust it!" – We are aware that the correction scheme does not cover all possible cases. However, we must ensure that all submissions are evaluated in the same way. We do not make changes to the scheme during the exam review.
- "I received no points because my solution was too vague. What I actually meant was..." – We evaluate only what you wrote on the exam. Subsequent explanations of your thought process are unnecessary.

## All Exercises

Follow-up errors and partial points are only awarded if explicitly provided for in the correction scheme.

In tasks where part of the solution involves selecting an answer, an incorrect response is evaluated as **0P**, except as mentioned below. Selecting the correct answer without providing an explanation is also evaluated as **0P**.

## Problem 1

### 1b

**2P** if the solution correctly points out (1) $(ab)^{2024}$ has length 4048, (2) this is the longest word in the language, and (3) those two facts imply that the NFA has at least 4048 states, but does not elaborate on why (3) is true.

**0P** if the solution assumes a specific construction for the NFA.

**0P** for an intuitive argument, e.g. "the NFA has to count the letters"

**0P** when using residual languages or equivalence classes

### 1c

**1P** if the automaton is correct for all non-empty words

### 1e

**-1P** if the $G$ is missing

**-1P** if the solution incorrectly models $\{p\}$ as formula $p$ instead of $p \land \neg q$

**0P** for solutions that are syntactically invalid, e.g. by using $\emptyset$ inside an LTL formula

### 1h

**3P** for recognising that we need to consider two accepting paths for words ending in $a^\omega$ and $b^\omega$, respectively, and that we need to combine those paths into a new accepted path not in the language, but not combining the paths correctly.

# Problem 2

## 2a

$+\mathbf{1P}$ for $L_1$ and $L_2$, $+\mathbf{2P}$ for $L_3$.

For $L_1$ and $L_2$, the point is given only if the solution consists of one single Rabin pair and is correct.

For $L_3$, **2P** only when the solution takes into account the following:

(a) For other semi-automata there exists a Rabin condition with one Rabin pair such that the resulting automaton recognizes $L_3$. Therefore, the argument showing that for *this* semi-automaton there is no such condition must *necessarily* use some specific property of *this* semi-automaton.

(b) It is not enough to show that no Büchi condition exists for the language. That alone does not preclude the existence of a Rabin condition.

## 2b

$+\mathbf{2P}$ for $L_1$, $+\mathbf{1P}$ for $L_2$ and $L_3$.

For $L_3$, the point is given only if the solution is correct.

For $L_1$, **2P** only if all four possible Büchi conditions are excluded.

# Problem 3

A formula which is wrong only on the empty word is considered correct in all subexercises.

## 3a

**3P** for a correct formula.

**2P** if a student expressed "$1 \in X$ and $x \in X \rightarrow (x+3) \in X$", which allows sets that are too large.

**2P** if a student almost wrote the correct formula, namely if he wrote the sample solution except $\rightarrow$ instead of $\leftrightarrow$.

**0P** otherwise.

### 3b

**3P** for a correct formula.

**2P** if the formula is satisfied exactly by $w \in (abb)^*$.

**0P** otherwise.

### 3c

**2P** for answering correctly and giving a correct family of formulas.

**2P** also for $x > k$, even though we did not allow this macro.

**1P** for formulas equivalent to $x > k+1$, more than one student tried to style on us and failed.

**0P** otherwise.

### 3d

**2P** for a correct answer and formula.

**0P** otherwise.

## Problem 4

If set brackets are missing in a student solution, then it is unclear whether the intention of the student with for example $p$ was $\{p\}$ or $\{p\} + \{p, q\}$.

This is even harder in a concatenation word. Hence such solutions are automatically 0 points, we do not interpret what they could have meant. Especially since for example in a) we explicitly specify $\Sigma$ as containing sets.

### 4a

**3P** for a correct solution

**2P** if $+\{p, q\}$ is missing under a $*$.

**2P** if symmetrically only $+\{p\}$ is missing.

**0P** otherwise.

### 4b

$+$**2P** for selecting everything correctly. Since the three formulas are not equivalent, selecting multiple formulas shows lack of understanding.

$+$**1P** each for the two counterexamples.

### 4c

Intuitive arguments without basis give **0P**.

**3P** for a fully correct answer.

One of the following main ideas is a necessary but not sufficient condition for points:

> $\mathsf{F}q$ is satisfied already at time 0 if it is ever satisfied.
>
> Prove equivalence to $\mathsf{F}q$ for both formulas.

## Problem 5

### 5a

**0P** points in total for algorithms that do not proceed as for the powerset construction: the elements of the workset must be sets of states, and a set $S$ must be processed by computing the sets $\delta(S, a)$ and $\delta(S, b)$.

**-2P** for ticking the wrong box.

**-1P** for each calculation error (wrong successor, wrong subsumption (or lack of)).

**-3P** for assuming that subsumption does not add $Q'$ to the workset when some set $Q'' \supseteq Q'$ was computed earlier, instead of when some set $Q'' \subseteq Q'$ was computed earlier.

### 5b

**0P** for giving a transition such that $N$ is no longer universal when the transition is deleted.

## Problem 6

### 6a

$+$**3P** for the insight that the languages decrease in length, or that only finitely many languages are reachable from $L_1$

$+$**1P** for the logical structure of the proof (only obtainable with the 3P from earlier)

**-1P** for the statement that $\{\varepsilon\}$ must be reached by every path starting in $L_1$

**-1P** for denoting the length of $L$ by $|L|$

An alternative solution argues with residual languages:

> **+3P** for the insight that each language in the path is a residual of $L_1$, and $L_1$ only has finitely many residuals
>
> **+1P** for an argument why $L_1$ only has finitely many residuals

### 6b

> **3P** if the solution gives a language from which both $R$ and $S$ are reachable, but fails to argue why

An alternative solution argues that $\{\varepsilon\}$ is reachable from $R$ and $S$ because e.g. $R^w = \{\varepsilon\}$ for every $w \in R$.

> **3P** if the solution points out that $\{\varepsilon\}$ is reachable from $R$ and $S$, but fails to argue why
>
> **1P** if the solution argues that $R$ and $S$ are connected to $\emptyset$ instead

### 6c

*Note:* Due to the wording of the exercise, it is ambiguous what the checkboxes mean. Hence during grading we ignored the checkboxes and instead inferred your choice based on the textual answer.

> **+2P** for giving a working example, this must consist of both a language $L$ and a corresponding infinite path of residuals.
>
> > If a unary $L$ is given, the path need not be explicitly specified and is assumed to be $(L^{a^i})_i$.
>
> **+2P** for arguing correctness of the example. In particular, it must be argued that the languages on the path are pairwise distinct.
>
> **0P** Answers that mention that non-regular languages have infinitely many residuals, but fail to construct a path (or otherwise argue existence of a path).

## Problem 7

### 7a

> **0P** for only doing projection on the first component and determinizing
>
> **-1P** if padding closure is not performed

### 7b

**0P** if you got 0P in (a)

**-1P** if padding closure is not performed

**-1P** for each mistake when executing the algorithm

**-1P** if the set of numbers is missing or not consistent with the resulting DFA