Dr. Karin Quaas
http://www.informatik.uni-leipzig.de/~quaas

„Real-Timed Automata“
Exercise 4

The following exercises must be submitted 23.06.2014 *before* the lecture.

We say that a timed automaton is *deterministic* if the set of initial locations is a singleton set, and for every pair of edges $(l, a, \phi_1, \lambda_1, l_1) \neq (l, a, \phi_2, \lambda_2, l_2)$, we have $\|\phi_1\| \cap \|\phi_2\| = \emptyset$ for all clock valuations ν. Here, $\|\phi\| = \{\nu \in (\mathbb{R}_{\geq 0})^X \mid \nu \models \phi\}$.

Correction: In the definition of L_2 in the proof of Theorem 5.5 (undecidability of the complementability problem), instead of requiring that the timed words contain either zero or exactly two c's, we require that the timed words contain either zero or *at least* two c's. The definition of L_3 does not change, i.e., it contains timed words with exactly one c.

1. Are the following claims correct? Justify your answer with a proof!
   (a) The emptiness problem for timed automata is undecidable, even if the timed automaton only uses two clocks.
   (b) The universality problem for timed automata with two clocks is undecidable.
   (c) The universality problem for timed automata with at most one clock is decidable.
   (d) Timed languages that are recognizable by a timed automaton with at most one clock are closed under complement.
   (e) Timed languages that are recognizable by a deterministic timed automaton are not closed under the complement operation.
2. Prove the following claim: *The problem to decide whether a recognizable timed language can be recognized by a deterministic timed automaton is undecidable.* Hint: Adapt the proof for the complementability problem (Theorem 5.5).