1. Below you see a Kripke structure; let’s call it $M$. Give its explicit definition in terms of a tuple etc (see the formal definition in the slides).

\[
\begin{align*}
\{ \text{stable, } x=0 \} & \rightarrow \{ \text{busy, } x>0 \} \\
\{ \text{busy, } x<0 \} & \rightarrow \{ x=0 \}
\end{align*}
\]

(a) Why don’t we have final states there?
(b) How is the notion of ’execution’ defined for a Kripke structure? And what is an ’abstract execution’?
(c) Give an execution of $M$ that satisfies the property $X (\text{busy } U (x=0))$. Does $M$ satisfies the property?
(d) So, given a property Kripke structure $M$, an (abstract) execution $\Pi$, and a property $\phi$, and an natural number $i$, what is the difference between:
   - $M \models \phi$
   - $\Pi \models \phi$
   - $\Pi, i \models \phi$

2. Express the following requirements in LTL. Make the necessary assumptions if you have to; but be reasonable.

(a) $P$ and $Q$ cannot not use a resource $r$ simultaneously.
(b) Whenever $P$ requests access to $r$, eventually it will get the access.
(c) Whenever $P$ requests access to $r$, eventually it will get the access; but only if $P$ persists on maintaining the request.
(d) $P$ cannot access $r$ without first requesting it; and it cannot do so (make a request) without first releasing $r$ (if it was busy using $r$).

3. Construct Buchi automata representing the following LTL formulas:

(a) $p \mathbf{W} q$, where $p, q$ are atomic propositions.
(b) $\neg(x>0 \ U x=y)$
(c) $p \ U (q \ U r)$, where $p, q$ are atomic propositions.
(d) $(X x>0) \ U x=y$
(e) $\Diamond \Diamond (x>0 \rightarrow x=y)$
(f) $(p \ U q) \mathbf{W} r$