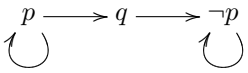
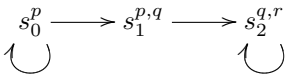
**Exercise 1.** What are the possible computations of




**Exercise 2.** Consider the finite state program




(The superscripts provide a list of the valid atomic propositions is a state.)

- $p\,U\,r$
- $p\,W\,r$
- $G(p \rightarrow F\,q)$
- $G(q \rightarrow F\,q)$

For each of these formulas:

- Check if it hold in the program.
- Describe the intuition behind the properties in words if possible.
- Give an equivalent Büchi automaton.

**Exercise 3.** When using decimal representation of non-negative real numbers, some numbers can have two representations. E.g. $0.999\cdots$ and $1.000\cdots$ represent the same number.

**a.** Give a Büchi automaton that recognizes only a single representation of each number.

**b.** Give an LTL formula that is true for precisely one representation of each number.

**Exercise 4.** Give both LTL and CTL formulas for the following statements:

**a.** Every $p$ is followed by a $q$.

**b.** Every $p$ is preceeded by a $q$.

Are the LTL and CTL versions equivalent in the sense that given a model both are true or both are false?

**Exercise 5.** Translate the following statements to both CTL and LTL if possible, or one of them otherwise.

**a.** At any time the reset button can be pushed.

**b.** As a result of pushing the reset button the system eventually reaches the restart state.

**c.** If we try to send a message infinitely often then eventually it will arrive.

**d.** Whenever $p$ is true, we can continue in such a way that $q$ becomes true.

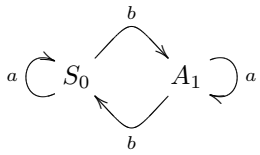
**Exercise 6.** Describe the following properties in words, expressing the intuition behind them:

**a.** $\mathsf{GF}\,r$

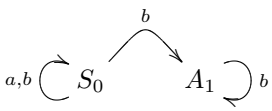
**b.** $\mathsf{EF}\,\mathsf{AG}\,p$

**Exercise 7.** Which strings are recognized by the Büchi automata

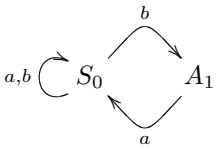
**a**




**b**




**c**




Initial state indicated by subscript 0, non-accepting states idicated with $S$ and accepting states indicated by $A$.