1.) Which ones of the following properties are safety properties? (See book Bédard et al., Chapter 7, p. 83–89). Give also a short argument in each case why your answer is correct.
   a) If in the initial state of the system a request arrives, it will be eventually acknowledged.
   b) In all states of the system it holds that an acknowledgement only arrives after a request has has been sent before.
   c) Whenever a request input becomes high, it stays high until an acknowledgement input becomes high.
   d) In all states of the system it holds that request stays high if the acknowledgement never becomes high.
   e) In all states of the system a request is followed in five time units by an acknowledgement.

2.) In the book (Bédard et al., Chapter 7.4, p. 87–89) the history variables method is described. The basic idea is to introduce a new Boolean variable \( h_i \) for each (past) temporal subformula, and initialize all of them to false in the initial state. After this the verification model is changed to record the changes to these history variables according to “rules” following the semantics of past temporal operators.

Let \( h_i' \) denote the value of the temporal subformula variable \( h_i \) in the previous time step, \( f_1, f_2 \) the values of variables corresponding to subformulas at the current time step, and finally \( f_1', f_2' \) the values of variables corresponding to subformulas at the previous time step.

Now the update rule for the formula \( h = X^{-1} f_1 \) (based on ) is:
   \[- h_i := f_i' \].

Give the update rules for all the other formula types:
   a) \( h_i = p \), for \( p \in AP \) (atomic propositions),
   b) \( h_i = \neg f_1 \),
   c) \( h_i = f_1 \lor f_2 \),
   d) \( h_i = G^{-1} f_1 \), and
   e) \( h_i = f_1 S f_2 \).

3.) Consider the automaton of Figure 7.1 of the book (Bédard et al., p. 87). Add history variables to the model to model check temporal formulas containing past time temporal operators by using a standard CTL model checker. (Use the translation scheme of the previous exercise (2.) above on this concrete case.) Also give the CTL formulas to model check in the following two cases:
   a) \( AG(X^{-1} alarm \Rightarrow F^{-1} crash) \)
   b) \( AG(F^{-1} alarm \Rightarrow ((crash \lor alarm)S(X^{-1} ok))) \)

Give the models with history variables added in expressions in similar style to Fig. 7.2, or notation similar to that of the exercise (2.) above, if the notation given in the book proves to be insufficient for the task.