1. Imagine a simple webshop where you can buy USB sticks. To make it simple, the shop only sells one kind of stick, and you can only buy one at a time. A typical interaction with the shop is (deliberately underspecified):

(a) The user clicks on the button *buy* to buy a stick. She will then be presented with a page specifying the price of stick, and a (secured) form where she can fill in her creditcard data.

(b) If the user agrees, she can click *ok*. The transaction is then confirmed. Otherwise she can *cancel*.

(c) She can repeat the procedure to buy more sticks.

(d) It is possible to click on *help* to get information on how to use the webshop.

Unfortunately, we don’t have a real implementation of this webshop, you will have to imagine one yourself.

(a) Come up with a Kripke structure that abstractly models your imaginary webshop. You can represent a page, and likewise a URL link, as a state in the Kripke structure. An arrow between two states $s$ and $t$ represents that either $s$ includes $t$ (if $s$ is a page containing link $t$), or if it is possible to directly navigate from $s$ to $t$, e.g. by clicking the URL link that $s$ represents.

We may need to enhance the states and arrows with additional information, as we proceed below to try to express certain properties of interest.

(b) The following are some properties that could be part of the webshop’s specification. Express them with LTL or CTL.

i. From any page, it should be possible to reach the help page.

ii. The user will not be charged double transactions if she accidentally clicks *ok* twice.

(c) Describe how CTL model checking works, then perform it to verify the above properties.

2. Consider the following Kripke structure:

$$\{p\} \xrightarrow{} \{p\} \xrightarrow{} \{p,q\} \xrightarrow{} 0$$

(a) Do LTL model checking to verify the LTL property $\Diamond\Box p$.

(b) Can the above property be expressed in CTL? How about in CTL*?

(c) Do CTL model checking to verify $EF(p \land q)$.

(d) Ok, now try these properties:

- $EF \neg p$
- $AG p$
3. Consider again the Kripke structure in No. 2.

(a) How would you describe it if you are to express with a Boolean formula?

(b) Do the model checking of the formula $EF(p \land q)$ on the symbolic representation of your Kripke.