Question 1

We will model a very simple virtual memory manager with two processes running. The memory has place for only one 4KB page, while each process has its own two 4KB pages. At any moment we want to know:

- Is the computer on?
- If the computer is on, which process is running?
  - one process runs at a time, and they do not halt.
- Which pages is currently loaded in the memory?

The following restrictions should be satisfied:

1) A memory page of a process P is loaded to memory only if P wants to interact (read/write) with the contents of that page (for example by a signal indicating that process i wants to interact with page j).

2) Whenever there is a context switch, the contents of the process that was running are moved back to the disk and the contents that were in memory of the new process before leaving are loaded back to the memory.

3) If the computer is just turned on, the memory is empty.

Model the system using a Statechart that responds to the requirements.

Describe each signal, whether it is internal or external, and what it represents.

Clarification: You are only required to model the computer state, there is no actual need to perform operations on the computer. For instance, when your Statechart transitions from state where page 1 of process 1 is in mem to state where page 2 of process 1 is in mem, you may assume the OS automatically takes care of unloading and loading the required pages.

Question 2

Using signals or in(state) expressions as the only atomic propositions, express the following properties (in LTL or CTL):

1) If a process wants to interact with a page, the page is eventually in memory

2) If there are infinite requests for the different pages of a process, then there are infinite memory page changes

3) If a page is in memory, then there was a moment in which that page was requested
Question 3

To which hierarchy class do these two formulas belong? (answer with the most precise category and justify your answer). The atomic propositions involved are p, q, r, t and u.

1. \( \neg \Box ((p \diamond q) \land \bigcirc r) \rightarrow ((t \lozenge u) \land \Box \neg u) \)
2. \( \Diamond (q \lozenge p) \land \Box q ) \)

Question 4

For every pair of formulas: state whether they are equivalent or not, and justify briefly when they are equivalent or present the corresponding counterexample when they are not.

1. \( AFGp \) and \( AFAGp \)
2. \( AFEFp \) and \( EFAPp \)
3. \( AGAFp \) and \( GFp \)

Good luck!