Exercise 1. Consider the following UML class diagram.

1. Express it in FOL.
2. Express it in DL-Lite, highlighting parts that are not expressible.
3. Given the ABox $A = \{C(a)\}$ and the conjunctive query $q(x) \leftarrow Rab(x, y), Rab(y, z), Rab(w, z)$, return the certain answer by exploiting the DL-Lite rewriting algorithm.

Exercise 2. Model check the Mu-Calculus formula $\nu X.\mu Y.((a \land \langle next \rangle X) \lor \langle next \rangle Y)$ and the CTL formula $AG(EXa \supset AXAXEGa)$ (showing its translation in Mu-Calculus) against the following transition system:

Exercise 3. Consider the following predicates: $Student(x)$, saying that $x$ is an student, $Exam(x)$, saying that $x$ is an exam, and $passed(x, y)$, saying that $x$ passed $y$. Express in FOL the following boolean queries, stating which ones are CQs (do not use abbreviations for cardinalities):

1. There exists a student that passed an exam.
2. There exists a student that passed exactly one exam.
3. There exists a student that passed at least two exams.
4. There exists a student that passed no exam.
5. There exists a student that passed all exams.
6. There exists two students such that the first passed all exams of the second one, but not viceversa.

Exercise 4. Given the following conjunctive queries:

$q_1(x) := edge(x, y), edge(y, y)$.
$q_2(x) := edge(x, y), edge(y, z), edge(x, z)$.

check whether $q_1$ is contained into $q_2$, explaining the technique used, and in case of containment showing the homomorphism between the canonical databases.

Exercise 5. Compute the weakest precondition for getting $\{x = y\}$ by executing the following program:

```plaintext
x := y + 1;
if (x > 0 & y >= 0) then {
  x := y - x;
  y := x - y
}
else if (x > 0) then
  x := x - y
```