Exercise 1. Express the following UML class diagram in FOL.

```
Exercise 2. Consider the above UML class diagram and the following (partial) instantiation.

```

1. Check whether the instantiation (once completed) is correct (and explain why it is or it is not).
2. Express in FOL and evaluate the following queries:
   (a) Return the all animals and the environment they inhabit.
   (b) Return the mammals that inhabit all environments.

Exercise 3. Model check the Mu-Calculus formula $\nu X.\mu Y.((a \land \langle\text{next}\rangle X) \lor \langle\text{next}\rangle Y)$ and the CTL formula $EFAGa \land EFAGb$ (showing its translation in Mu-Calculus) against the following transition system:

```
Exercise 4. Consider the following program:

```
while (x<10) do x := x + 5
```

Compute its execution and final state, starting from an initial state where $x = 1$, using:
1. evaluation semantics;
2. transition semantics.

Exercise 5. Given the following conjunctive queries:

```
q1(x) :- r(x,y), r(y,y), r(y,z), r(z,x).
q2(x) :- r(x,y), r(x,z), r(x,v), r(y,w), r(w,x), r(z,w), r(v,z).
```

check whether $q1$ is contained into $q2$, explaining the technique used and, in case of containment, showing the homomorphism between the canonical databases.