# Midterm Test — March 3, 2022

Duration: 80 minutes
No Aids Allowed
Total marks: 70

**Name:**

**Student Number:**

| | |
|---|---|
| 1) | /5 |
| 2) | /10 |
| 3) | /10 |
| 4) | /5 |
| 5) | /20 |
| 6) | /10 |
| 7) | /10 |
| Total | /70 |

1. [5 points] For each of the following statements indicate whether it is *true* or *false*:

   (a) In general, for a first-order logic knowledge base KB and query $\phi$, checking whether KB entails $\phi$ is *decidable*.

   (b) In general, for a propositional logic knowledge base KB and query $\phi$, checking whether KB entails $\phi$ is *decidable*.

   (c) In general, checking whether a set of first-order Horn clauses is satisfiable is *decidable*.

   (d) In general, for an $\mathcal{ALC}$ description logic knowledge base KB and query $\phi$, checking whether KB entails $\phi$ is *decidable*.

   (e) Resolution is *sound*, i.e., if a clause $c$ can be derived by resolution from a set of clauses $S$, then $S$ entails $c$.

2. [10 points] Explain in a line or two each of the following:

   **a)** closed-world asssumption

   **b)** Horn clause

   **c)** minimal entailment

   **d)** nonmonotonic reasoning

   **e)** SLD resolution

3. [10 points] Translate the following English sentences into first-order logic:

   (a) Every person has a parent.

   (b) No student failed all courses.

   (c) There is a question that every student knows the answer to.

   (d) All but one of the puppies are healthy.

   (e) A professor is happy if he/she belongs to no committees.

4. [5 points] Skolemizing a CNF formula does not preserve logical equivalence. For example, if we skolemize $\exists x P(x)$, we get $P(a)$, which is not logically equivalent to the original formula. Yet, skolemization works when one does resolution proofs. Briefly explain why.

5. [20 points] Suppose that we have the following knowledge base (KB) represented as a set of FOL sentences about three elephants, Sam, Clyde, and Oscar:

   **(1)** $Pink(sam)$ Sam is pink.

   **(2)** $Gray(clyde)$ Clyde is gray.

   **(3)** $Likes(clyde, oscar)$ Clyde likes Oscar.

   **(4)** $Pink(oscar) \vee Gray(oscar)$ Oscar is either pink or gray.

   **(6)** $\neg Pink(oscar) \vee \neg Gray(oscar)$ Oscar is not both pink and gray.

   **(6)** $Likes(oscar, sam)$ Oscar likes Sam.

   (a) Prove that the KB does *not* entail that *Oscar is pink*. That is, show that there is an interpretation that satisfies the KB but does not satisfy this conclusion.

(b) Using the definition of entailment in terms of interpretations, prove that the KB *entails* that *some grey elephant likes some pink elephant*. Show how the query is expressed in first-order logic and give a detailed proof. *Do not use resolution.*

6. [10 points] Use the tableau method for $\mathcal{ALC}$ described in Baader and Sattler's paper to check whether the following concept is satisfiable/consistent. Show the steps and rules that are used. If the concept is satisfiable give the model(s) (satisfying interpretation(s)) obtained by the method.

$$((\forall R.(\exists R.A)) \sqcap (\exists R.B)) \sqcap (\forall R.((\forall R.\neg A) \sqcup (\forall R.\neg B)))$$

7. [10 points]

**a)** What are the extension(s) of the default logic theory $\langle \mathcal{D}, \mathcal{F} \rangle$, where

$$\mathcal{D} = \{\langle\ TruckDriver(x) \Rightarrow BeerDrinker(x)\rangle\} \text{ and}$$

$$\mathcal{F} = \{Sailor(john), TruckDriver(bob)\}?$$

**b)** What are the extension(s) of the default logic theory $\langle \mathcal{D}, \mathcal{F} \rangle$, where

$$\mathcal{D} = \{\langle\ TruckDriver(x) \Rightarrow BeerDrinker(x)\rangle\} \text{ and}$$

$$\mathcal{F} = \{Sailor(john), (TruckDriver(bob) \vee TruckDriver(paul))\}?$$

**c)** What are the extension(s) of the default theory $\langle \mathcal{D}, \mathcal{F} \rangle$, where

$$\mathcal{D} = \{\langle\, TruckDriver(x) \Rightarrow BeerDrinker(x)\rangle, \langle\, DoesYoga(x) \Rightarrow \neg BeerDrinker(x)\rangle\}$$

and $\mathcal{F} = \{TruckDriver(john), DoesYoga(john), TruckDriver(bob)\}$?