Försättsblad till skriftlig tentamen vid Linköpings universitet

Datum för tentamen	2019-04-25
Sal (1)	TER2(21)
Tid	14-19
Utb. kod	TDDD72
Modul	TEN1
Utb. kodnamn/benämning **Modulnamn/benämning**	Logik En skriftlig tentamen
Institution	IDA
Antal uppgifter som ingår i tentamen	4
Jour/Kursansvarig Ange vem som besöker salen	Andrzej Szalas (examinator är utomlands)
Telefon under skrivtiden	013-28 19 95 eller 0709 46 1995
Besöker salen ca klockan	ja Victor Lagerkvist besöker salen för frågor
Kursadministratör/kontaktperson (namn + tfnr + mailaddress)	Anna Grabska Eklund, ankn. 2362, anna.grabska.eklund@liu.se
Tillåtna hjälpmedel	You can use your own copies of slides as well as an English-Swedish dictionary.
Övrigt	
Antal exemplar i påsen	

EXAM: TDDD72 (LOGIC)

26 APRIL 2019

Exam rules

1. You can use your own copies of slides from lectures as well as an English-Swedish dictionary.

2. Exercises are formulated in English, but answers can be given in English or in Swedish.

3. You are not allowed to:

   - use any writing material other than indicated in point 1, in particular you cannot use ebook with exercises and solutions;
   - use calculators, mobile phones or any other electronic devices;
   - lend/borrow/exchange anything during the exam.

4. If an exercise has not been specified completely as you see it, state which (reasonable) assumptions you have made.

5. Begin each exercise on a new sheet of paper. Write only on one side of the paper. Write clearly and make sure to give adequate explanations for all your answers.

6. There are 4 exercises, each exercise gives maximum 10 points (40 points together). Grading is provided in the following table.

number of points (n)	grade
$34 \leq n \leq 40$	5
$27 \leq n < 34$	4
$20 \leq n < 27$	3
$n < 20$	U (not passed)

EXERCISES

EXERCISE 1

1. Prove the following propositional formula:

$$[(Q \to \neg P) \wedge R] \to [\neg P \vee (\neg Q \wedge R)]$$

   (a) (*2 points*) using Gentzen system;

   (b) (*2 points*) using tableaux.

2. Prove the following formula of first-order logic, where a is a constant:

$$\forall x \exists y \exists z \Big(P(x, y, z) \vee \neg \exists z \exists u (\neg P(x, z, u)) \Big) \to \exists x \exists y P(a, x, y)$$

   (a) (*3 points*) using resolution;

   (b) (*3 points*) using tableaux.

EXERCISE 2

1. (*4 points*) Translate the following sentences and assumptions into a set of propositional formulas:

   "Pick a white object or a black object or a brown object."
   "White objects are small."
   "Black objects are of medium size."
   "Brown objects are big."
   "The picked object should be small or big. It should be white or should not be brown."

2. (*2 points*) Hypothesize and explain informally what choice as to the picked parcel's color can be made, assuming that:

   - each object is white or black or brown;
   - each object is colored with one color only and has exactly one size;
   - the robot can pick only one object.

3. (*4 points*) Prove your claim formally using a proof system of your choice (tableaux, Gentzen system or resolution).

EXERCISE 3

Consider the following properties of a binary relation R:

$$\forall x \forall y \forall z[R(x,y) \to (R(x,z) \to R(y,z))]; \quad (1)$$
$$\forall x \forall y \forall z[R(x,y) \to (R(y,z) \to R(z,x))]; \quad (2)$$
$$\exists x \forall y[R(x,y) \to R(y,x)]. \quad (3)$$

(1) (*4 points*) Prove informally that $((1) \land (2)) \to (3)$.

(2) (*6 points*) Prove formally (using tableaux, Gentzen system or resolution) that $((1) \land (2)) \to (3)$.

EXERCISE 4

(a) *(2 points)* Design a Datalog database for storing information about cars. Each car is characterized by its price (low, medium, high), size (small, medium, large) and age (old, medium, new). In addition, for each pair of cars c_1, c_2, the database contains information whether c_1 is directly more popular than c_2, where:

> a car c_1 is *directly more popular than* a car c_2 if c_1 is more popular than c_2 and there are no cars between c_1 and c_2 wrt their popularity. (4)

- *(1 point)* Let $x \succ y$ denotes that the car x is directly more popular than car y. Express in predicate calculus the definition (4).
- *(1 point)* Provide an integrity constraint concerning the relation $\succ$.
- Formulate in logic queries selecting:
  1. *(2 points)* all small, old cars with low or medium price;
  2. *(4 points)* all large, medium price cars which are more popular (not necessarily directly) than a given car, where "more popular" is defined by:

     a car z is *more popular* than u if $z \succ u$ or there is $n \geq 1$ and cars $c_1, \ldots, c_n$ such that $z \succ c_1 \succ c_2 \succ \ldots \succ c_n \succ z$.