Försättsblad till skriftlig tentamen vid Linköpings universitet

Datum för tentamen	2016-10-26
Sal (4)	U4 U6 U7 U10
Tid	8-12
Kurskod	TDDD88
Provkod	TEN1
Kursnamn/benämning **Provnamn/benämning**	Logik En skriftlig tentamen
Institution	IDA
Antal uppgifter som ingår i tentamen	4
Jour/Kursansvarig Ange vem som besöker salen	Olov Andersson
Telefon under skrivtiden	ankn. 2069 eller 070 574 33 43
Besöker salen ca klockan	ja
Kursadministratör/kontaktperson (namn + tfnr + mailaddress)	Anna Grabska Eklund, ankn. 2362, anna.grabska.eklund@liu.se
Tillåtna hjälpmedel	1. You can use your own copies of compendium (extract from slides) 2. English-Swedish dictionary.
Övrigt	
Antal exemplar i påsen	

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EXAM: TDDD88 (LOGIC)

26 OCTOBER 2016

Exam rules

1. You can use your own copies of compendium (extract from slides) 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 full slides or 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:

$$[(P \to \neg Q) \leftrightarrow \neg P] \to [Q \vee \neg P]$$

   (a) (*2 points*) using tableaux;

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

2. Prove the following formula of first-order logic:

$$\forall x \forall y \forall z[(R(x,y) \wedge R(x,z)) \to R(y,z)] \to \exists x \forall y[R(x,y) \to R(y,y)]$$

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

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

EXERCISE 2

1. (*4 points*) Translate the following sentences into a set of propositional formulas, where *Rob* is a robot:

   " If *Rob* will not find its target then it will return to the base or will contact the operator."
   " If *Rob* will return to the base and its batteries will be reloaded then it will find its target."
   " If batteries of *Rob* will not be reloaded then *Rob* will find its target or will contact the operator."
   " If *Rob* will contact the operator then it will find its target."

2. (*2 points*) Check informally whether sentences expressed in point 1 imply that *Rob* will find its target.

3. (*4 points*) Prove your claim formally using tableaux or resolution.

EXERCISE 3

Consider relations L and M among persons:

(a) $L(x, y)$ intuitively meaning that x likes y;

(b) $M(x, y)$ defined by $\forall x \forall y[M(x, y) \leftrightarrow (L(x, y) \wedge L(y, x))]$ and intuitively meaning that x and y like each other.

(1) *(1 point)* Express in first-order logic the property of L that everybody likes somebody and everybody is liked by somebody.

(2) *(3 points)* Assuming the transitivity and symmetry of M together with the additional property that $\forall x \exists y[L(x, y) \wedge L(y, x)]$ and the definition of M given in (b) prove informally that M is reflexive.

(3) *(6 points)* prove (2) formally, using resolution or tableaux.

Recall that relation M is:

- reflexive, if $\forall x[M(x, x)]$;
- symmetric, if $\forall x \forall y[M(x, y) \rightarrow M(y, x)]$;
- transitive, if $\forall x \forall y \forall z[(M(x, y) \wedge M(y, z)) \rightarrow M(x, z)]$.

EXERCISE 4

1. *(2 points)* Design a Datalog database for storing information about car accidents involving exactly two cars. The database should contain information about:

   - cars: for each car its production year and purchase price;
   - accidents: for each accident two cars and two drivers involved.

   A driver d is *directly linked to* driver d', which is denoted by $d \leftrightsquigarrow d'$, if d, d' have been involved in the same car accident.

   A driver d is *indirectly linked to* driver d' if there is $k \geq 1$ and drivers $d_0, \ldots, d_{k+1}$ such that $d_0 = d$ and $d_{k+1} = d'$, and $d \leftrightsquigarrow d_1, \ldots, d_{k-1} \leftrightsquigarrow d_k, d_k \leftrightsquigarrow d'$.

2. *(1 point)* Express in first-order logic the constraint:

   "each accident has a unique pair of cars and a unique pair of drivers involved."

3. *(1 point)* Provide a sample integrity constraint concerning direct link relation among drivers.

4. Formulate Datalog queries selecting:

   (a) *(2 points)* all pairs of cars c_1, c_2 such that c_1, c_2 have been involved in the same accident, c_1 is older than 10 years, and c_2 has been purchased in 2016 or c_2's purchase price is greater than 120 000 SEK;

   (b) *(4 points)* all drivers directly of indirectly linked to drivers who participated in a car accident involving a car whose purchase price is greater than 200 000 SEK.