Försättsblad till skriftlig tentamen vid Linköpings universitet

Datum för tentamen	2016-01-15
Sal (1)	TB
Tid	8-13
Kurskod	TDDD72
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	Andrzej Szalas
Telefon under skrivtiden	013-28 19 95 eller 0709 46 1995
Besöker salen ca klockan	ja
Kursadministratör/kontaktperson (namn + tfnr + mailaddress)	Anna Grabska Eklund, ankn. 2362, anna.grabska.eklund@liu.se
Tillåtna hjälpmedel	1You can use your own copies of slides as well as an English-Swedish dictionary. 2. Exercises are formulated in English, but answers can be given in English or Swedish.
Övrigt	
Antal exemplar i påsen	

EXAM: TDDD72 (LOGIC)

15 JANUARY 2016

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:

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

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

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

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

$$\forall x \exists y \forall z \Big(P(x, y, z) \vee P(z, y, x) \Big) \rightarrow \forall x \exists y \exists z \Big(P(x, y, z) \vee P(z, y, x) \Big)$$

   (a) (*3 points*) using Gentzen system;

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

EXERCISE 2

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

   " If 'Co' will offer a new product then it will not take a loan or will have cash flow problems."
   " If 'Co' will not take a loan and its income will decrease then it will not offer a new product."
   " If the income of 'Co' will not decrease then 'Co' will not offer a new product or will have cash flow problems."
   " If 'Co' will have cash flow problems then it will not offer a new product."

2. (*2 points*) Check informally whether sentences expressed in point 1 imply that 'Co' will not offer a new product.

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

EXERCISE 3

Consider relation $R(x, y)$ being symmetric and transitive and such that:

$$\forall x \exists y [R(x, y)]. \tag{1}$$

(a) *(4 points)* assuming (1) together with symmetry and transitivity of R, prove informally that R is reflexive;

(b) *(6 points)* prove (a) formally, using resolution or Gentzen system.

Recall that relation R is:

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

EXERCISE 4

1. *(2 points)* Design a Datalog database for storing information about events. Each event is characterized by its importance (*low, medium or high*) and safety level (*low, medium or high*). In addition, the database should contain information about causal relationship among events, allowing one to express that a given event is a direct cause of another event.

   An event e' is *indirectly caused* by event e if there is a natural number $k \geq 1$ and events $e_1, e_2, \ldots, e_k$ such that:

   - e_1 is caused by e;
   - e_2 is caused by e_1;
   - ...
   - e_k is caused by e_{k-1};
   - e' is caused by e_k.

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

   "an event has a unique importance and safety level."

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

4. Formulate Datalog queries selecting:

   (a) *(2 points)* all pairs of events e, e' such that e is an event with low or medium safety level and e' is an event of high importance, directly caused by e;

   (b) *(4 points)* all events e of medium or high importance, being a direct or indirect cause of an event with low safety level.