Försättsblad till skriftlig tentamen vid Linköpings universitet

Datum för tentamen	2017-01-05
Sal (1)	TER2(13)
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	Tommy Persson
Telefon under skrivtiden	ankn. 4497
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	

EXAM: TDDD88 (LOGIC)

5 JANUARY 2017

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:

$$[(P \rightarrow Q) \rightarrow \neg P] \rightarrow [P \rightarrow \neg Q]$$

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

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

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

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

   (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 and will contact the operator."
   "If *Rob* will return to the base then its batteries will be reloaded."
   "If *Rob*'s batteries will be reloaded then *Rob* will contact the operator and will continue."
   "If *Rob* will continue 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 a set of towns. Some towns are connected by trains. There might also be trains connecting places inside of towns. Trains connecting different towns are called *external* and those connecting places within a single town are called *internal*.

Assume that $C(x, y)$ expresses the fact that towns x and y are connected by trains.[1] Assume also that the following properties are satisfied:

(i) for every town x there is town y such that $C(x, y)$ and $C(y, x)$;

(ii) for all towns x, y, z, whenever there is a train connection between x and y and between y and z then there is also a train connection between x and z.

Please:

1. (*1 point*) express in predicate logic properties (i) and (ii);
2. (*3 points*) check informally whether the conjunction of (i) and (ii) implies that "every town has an internal train";
3. (*6 points*) verify your informal reasoning using a proof system of your choice (tableaux or resolution).

EXERCISE 4

1. *(2 points)* Design a Datalog database for storing information about:
   - companies cooperating to achieve a common goal;
   - tasks to be completed, where each task is either *required* or *optional*.

   For each company there should be an information about tasks it is responsible for and subcontractors it hires. Each subcontractor can also hire its subcontractors.

   A company c is *directly hiring* company c', which is denoted by $c \rightsquigarrow c'$, if c' is a subcontractor of c. A company c is *indirectly hiring* company c' if there is $k \geq 1$ and companies $c_0, \ldots, c_{k+1}$ such that $c_0 = c$ and $c_{k+1} = c'$, and:
   $$c_0 \rightsquigarrow c_1 \rightsquigarrow \ \ldots \ \rightsquigarrow c_k \rightsquigarrow c_{k+1}.$$
2. *(1 point)* Express in first-order logic the constraint:
   "each task can be either required or optional.[2]"
3. *(1 point)* Provide a sample integrity constraint concerning direct hiring relation among companies.
4. Formulate Datalog queries selecting:
   (a) *(2 points)* all companies c_1, c_2 such that c_1 directly hires c_2 and c_2 is responsible for at least two required tasks;
   (b) *(4 points)* all companies responsible for at least one optional task, directly or indirectly hired by a given company.

[1] Note that $C(x, x)$ states that there is an internal train in town x.
[2] In particular, no task can be both required and optional.