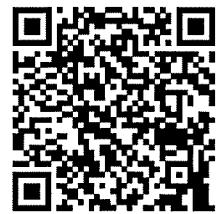


Försättsblad till skriftlig tentamen vid Linköpings universitet



| | |
|--|--|
| 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:

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

- (a) (2 points) using tableaux;
- (b) (2 points) using resolution.

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

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

- (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 $d \rightsquigarrow d'$, 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, \dots, d_{k+1} such that $d_0 = d$ and $d_{k+1} = d'$, and $d \rightsquigarrow d_1, \dots, d_{k-1} \rightsquigarrow d_k, d_k \rightsquigarrow d'$.

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 or indirectly linked to drivers who participated in a car accident involving a car whose purchase price is greater than 200 000 SEK.