

# Försättsblad till skriftlig tentamen vid Linköpings universitet



Datum för tentamen	2019-01-14
Sal (2)	TER1(69) TERE(3)
Tid	8-13
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	Tommy Persson
Telefon under skrivtiden	013-28 44 97
Besöker salen ca klockan	ja ca 09:30
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)

14 JANUARY 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:

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

- (a) (2 points) using Gentzen system;  
(b) (2 points) using tableaux.
2. Prove the following formula of first-order logic:

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

- (a) (3 points) using resolution;  
(b) (3 points) using tableaux.

## EXERCISE 2

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

“Parcels are heavy, of moderate weight or light.”  
“Heavy parcels are red.”  
“Parcels of moderate weight are green.”  
“Light parcels are blue.”  
“Chose a green parcel or a parcel not being red.”  
“Chose a blue parcel or a parcel not being green.”

2. (2 points) Assuming that each parcel has a unique color and exactly one parcel is to be chosen,
- hypothesize what choice as to parcel's color can be made;
  - explain your reasoning informally.
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  $R$ :

- (a)  $\forall x \forall y \forall z [R(x, y) \rightarrow (R(y, z) \rightarrow R(z, x))]$ ;
- (b)  $\forall x \forall y \forall z [R(x, y) \rightarrow (R(x, z) \rightarrow R(y, z))]$ ;
- (c)  $\exists x \forall y [R(x, y) \rightarrow R(y, x)]$ .

- (1) (4 points) Prove informally that  $((a) \wedge (b)) \rightarrow (c)$ .
- (2) (6 points) Prove formally (using tableaux, Gentzen system or resolution) that  $((a) \wedge (b)) \rightarrow (c)$ .

## EXERCISE 4

1. (2 points) Design a Datalog database for storing information about employees (including position and salary) as well as information about the *direct supervisor* relationship among employees.

By  $e' \rightsquigarrow e''$  we denote that  $e'$  is a direct supervisor of  $e''$ .

We define that employee  $e'$  is an *indirect supervisor* of employee  $e''$  if there is  $k \geq 1$  and employees  $e_1, e_2, \dots, e_k$  such that:

$$e' \rightsquigarrow e_1 \rightsquigarrow e_2 \rightsquigarrow \dots \rightsquigarrow e_{k-1} \rightsquigarrow e_k \rightsquigarrow e''.$$

2. (1 point) Express in predicate calculus the constraint:
 

“the relationship of being an indirect supervisor is transitive.”
3. (1 point) Provide another integrity constraint concerning direct supervisor relationship.
4. Formulate in logic queries selecting:
  - (a) (2 points) all employees being direct supervisors of software engineers or database experts;
  - (b) (4 points) all pairs of employees  $X, Y$  such that  $X$  is a direct or indirect supervisor of  $Y$ , and  $X$  has a lower salary than  $Y$ .