TIE329 Automated Reasoning (2 ov)
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## Exam on April 16, 2004

**Read the instructions carefully!**

*This exam consists of three mutually exclusive problems. That means that you should do only one of them.*

*The three problems are of varying difficulty, and each has an associated maximum grade:*

- *The first problem tests for basic understanding. If you do the first problem, the maximum grade is* 1.5.
- *The second problem tests for working understanding. If you do the second problem, the maximum grade is* 2+.
- *The third problem tests for understanding of concepts in their context and their relationships. If you do the third problem, the maximum grade is* 3.

*If you do more than one, they are all graded independently of each other and the best grade is used.*

Turn the page!

*Do one of A, B and C.*

## Problem A

*Maximum grade obtainable from this problem is* 1.5.

Answer THREE (3) of the following questions.

1. What are first-order structures?
2. How are the semantics of first-order languages defined?
3. What is the dual clause form algorithm (sentential case)?
4. What is the sentential resolution rule? (Please, include a rough proof of its soundness.)
5. Define Skolemization with examples.

## Problem B

*Maximum grade obtainable from this problem is* 2+.

Answer THREE (3) of the following questions.

1. How are the semantics of first-order languages defined?
2. Derive, with explanations, the Lis–Smullyan uniform notation table for signed first-order formulae (the table of $\alpha$, $\beta$, $\gamma$ and $\delta$ formulae).
3. Define the unification problem and give a unification algorithm. Sketch a proof for its correctness.
4. Is
$$(\exists x)(\forall y)((p(x,y) \wedge \neg p(y,x)) \rightarrow ((p(x,x) \leftrightarrow p(y,y))))$$
valid or not? Use *free-variable tableaux*.
5. Explain how Herbrand's theorem might be used to lift a sentential proof procedure into a first-order proof procedure.

## Problem C

*Maximum grade obtainable from this problem is* 3.

Draw a rough mind map of the concepts that you feel are central to automated reasoning, and their relationships. Also write an essay where you elaborate on the concepts and relationships, and where you explain and argue for your choices. In the essay, do include a brief definition of each concept, and do include examples!