

# Automated Reasoning Ph.D. Qualifier Exam

September 22, 2005

**Note:** This is a closed book, closed notes, closed internet exam.

1. Let  $M$  be a mathematical structure,  $\phi$  a predicate formula,  $\Delta$  a set of predicate formulas, and  $R$  a method of inference (e.g., modus ponens or resolution). Provide a brief definition of the following terms:
  - (a)  $M$  is a *model* of  $\phi$ .
  - (b)  $\Delta$  *satisfies*  $M$ .
  - (c)  $\phi$  is *satisfiable*.
  - (d)  $\phi$  is a *logical consequence* of  $\Delta$ .
  - (e)  $\phi$  is *valid*.
  - (f)  $R$  is *complete*.
  - (g)  $R$  is *sound*.
2. Consider the following statements:
  - (a) Everyone who feels warm either is drunk or every costume they have is warm.
  - (b) Every costume that is warm is furry.
  - (c) Every AI student is a CS student.
  - (d) Every AI student has some robot costume.
  - (e) No robot costume is furry.
  - (f) (Conclusion) If every CS student feels warm, then every AI student is drunk.

Notice that the first five statements (i.e., the hypotheses) can be used to prove the last statement (i.e., the conclusion).

- Convert the given statements into predicate (first-order) logic.
- Convert the statements into clausal form, suitable for resolution.
- Derive a proof of the conclusion by using resolution on the resulting set of clauses.

3. Write an algorithm (pseudo-code is OK) for unifying two terms.