

**Question 1(15 pts):**

If the unicorn is mythical then it is immortal. But if it is not mythical then it is a mammal. If the unicorn is either immortal or mammal then it is horned. Prove or disprove or show that nothing can be said about:

- Unicorn is mythical.
- Unicorn is magical.
- Unicorn is horned.

**Question 2 (20 pts):**

You are given the following predicate symbols (which return true or false):

Mother( $m, x$ ) true when  $m$  is mother of  $x$ ,  
Father( $f, x$ ) true when  $f$  is father of  $x$ ,  
Female( $x$ ) true when  $x$  is female,  
Sister( $s, x$ ) true when  $s$  is sister of  $x$ ,  
Brother( $b, x$ ) true when  $b$  is brother of  $x$ ,  
Cousin( $c, x$ ) true when  $c$  is cousin of  $x$ .

Using these predicates, rewrite the following sentences:

- Not every one has a brother
- If one has a sister, the sister is female
- If one has the same mother and father as some other person, that other person is either one's brother or one's sister
- One's cousin is someone whose father or mother is a sister or brother of one's mother or father

**Question 3 (25 pts):**

This exercise can be done without the computer, although you may find it useful to use a backward chainer to check your proof for the last part. The idea is to formalize the blocks world domain using the situation calculus. The objects in this domain are blocks, tables, and situations. The predicates are:

$On(x, y, s)$      $ClearTop(x, s)$      $Block(x)$      $Table(x)$

The only action is  $PutOn(x, y)$ , where  $x$  must be a block whose top is clear of any other blocks, any  $y$  can be either the table or a different block with a clear top. The initial situation  $S_0$  has **A** on **B** on **C** on the table.

- a. Write an axiom or axioms describing  $PutOn$ .

- b. Describe the initial state,  $S_0$ , in which there is a stack of three blocks, **A** on **B** on **C**, where **C** is on table, **T**.
- c. Give the appropriate query that a theorem prover can solve to generate a plan to build a stack where **C** is on top of **B** is on top of **A**. Write down the solution that the theorem prover should return. (*Hint*: The solution will be a situation described as the result of doing some actions to  $S_0$ ).

**Question 4 (30 pts):**

Write down logical representations for the following sentences, suitable for use with Generalized Modus Ponens:

- a. Horses, cows, and pigs are mammals.
- b. An offspring of a horse is a horse.
- c. Bluebeard is a horse.
- d. Bluebeard is Charlie's parent.
- e. Offspring and parent are inverse relations.
- f. Every mammal has a parent.

**Question 5 (10 pts):**

How can resolution be used to show that a sentence is:

- a. Valid?
- b. Unsatisfiable?