4511W, Fall-2019
ASSIGNMENT 5:
Assigned: 11/20/19 Due: 11/26/19 at 11:55 PM (submit via Canvas, you may take a picture of handwritten solutions, but you must put them in a pdf) Submit only pdf or txt files

Written/drawn:

Problem 1. (10 points)
Below is a small minesweep board with some numbers filled in. The numbers indicate how many mines are surrounding the cell in all 8 adjacent cells. "?"s indicate cells that you do not know the value or whether a mine is present.
(1) Write out all the models that satisfy the rules of minesweep for where the mines can be placed. Your representation of a model is up to you (i.e. does not have to be in logic).
(2) Based off your answer from part (1), what mines, if any, can you conclude the locations of? (Specify the locations.)
(3) Based off your answer from part (1), what squares, if any, can you conclude must have no mine (i.e. are safe to play).

?	?	1	0
3	?	2	1
?	?	?	?
?	3	2	?

Problem 2. (10 points)
Translate the KB below into CNF (conjunctive normal form). Sentences on separate lines are assumed ANDed together.

$$B \lor D \lor E$$
$$C \Rightarrow (D \lor A)$$
$$(E \lor A) \Rightarrow B$$
$$(A \lor B) \iff (C \lor (D \land E))$$

Problem 3. (20 points)
Suppose you have the KB as shown below. Use resolution (and show work... like always) to find if:
(1) KB $\models B$
(2) KB $\models E$
(3) KB $\models (B \lor E)$
KB:
$(A \lor \neg B \lor \neg C \lor D)$
$(B \lor \neg C)$
$(\neg A \lor D \lor \neg E)$
$(\neg C \lor D \lor \neg E)$
$(B \lor \neg D \lor E)$
$(C \lor \neg D \lor \neg E)$
$(B \lor C \lor D \lor E)$

Problem 4. (20 points)

Below are some English paragraphs describing a situation. Convert the relevant parts into first order logic. The relations (with number of inputs in parenthesis) to use are, and none of these are functions: Dad(2), EatApple(1), Mom(2), Person(1), Unicorn(1), WhiteHorn(1)

There is a secret base on the dark side of the moon filled with unicorns for research. These unicorns must eat to stay alive, but what they consume can vary. Unicorns with a bone-white horn eat only apples, while rainbow-colored horned unicorns eat moon dust (unicorns only have one horn). The people taking care of the unicorns like the apples too.

The unicorn horn color is a heritable trait: if the mother and father unicorn have the same color horn (regardless of which parent), then the child will have a bone-white horn. Otherwise (if the parents have different colored horns), the child will have a rainbow-colored horn.

Problem 5. (10 points)

Use forward chaining on the KB below (show work... as always) to generate all things you can infer (i.e. say all new facts that you can deduce)

KB:
$$\forall x \ Planet(x) \Rightarrow \exists y \ Star(y) \land Orbit(x, y)$$
$$\forall x \ Star(x) \iff Fusion(x)$$
$$\forall x \ Planet(x) \iff \neg Star(x)$$
$$\forall x \ Fusion(x) \Rightarrow Large(x) \land Hot(x)$$
$$\forall x \ Satellite(x) \Rightarrow \exists y \ \neg Star(y) \land Orbit(x, y)$$
$$Planet(Earth)$$
$$\exists x \ Satellite(x)$$
$$Large(Jupiter) \land Hot(Jupiter)$$
$$Star(Sun)$$

Problem 6. (20 points)

Use resolution to determine (show work... as always) if KB entails α, where:

$$\alpha = \forall x \ \exists y \ S(f(f(f(Cat))), x, y)$$

KB:
$$\forall x \ S(Cat, x, x)$$
$$\forall x, y, z \ \big(\neg S(x, y, z) \lor S(f(x), y, f(z))\big)$$

Programming (python/lisp):

Problem 7 (was misnumbered as "8"). (10 points)

Use logic.py provided (otherwise you might get a compile error) to setup a propositional logic knowledge base (i.e. "KB") of problem 2 using the tell() commands. (As always, you can check out the /tests/ folder for example usage.) Then use this code to answer the following questions:

(1) Is the following true: KB $\models (A \land B) \lor D$

(2) Is the following true: KB $\models (E \lor D)$