4511W, Fall-2021
ASSIGNMENT 6:
Assigned: 12/7/21 Due: 12/14/21 at 11:55 PM (submit on gradescope, mark the page(s) associated for each problem when submitting). Show work for full credit.

Problem 1. (10 points)
Convert the following into CNF (conjunctive normal form) while remaining in first-order logic:
(1)
$$\forall x \ (A(x) \vee B(x)) \Rightarrow (\forall y \ C(x,y) \vee D(y))$$

(2)
$$\forall x \ \forall y \ (A(x,y) \wedge \exists z \ B(y,z)) \Rightarrow \exists z \ C(x,z)$$

Problem 2. (20 points)
Use resolution in first-order logic to find if the following α is entailed from this KB:
$\alpha = C(Moo, Moo)$

KB:
$\neg A(x) \vee B(f(x)) \vee C(x, f(x))$
$f(x) = x \vee \neg A(x)$
$f(Cat) = Moo$
$A(Cat) \vee C(f(x), Moo)$
$\neg B(Cat)$

Problem 3. (20 points)
Use resolution to determine if the following first-order logic sentences can entail α. You must be clear on your substitution/unification.
$$\alpha = \forall x \ \exists y \ A(x, f(f(Snail)), y)$$

KB:
$$\forall x \ A(x, Snail, x)$$
$$\forall x, y, z \ (\neg A(x, y, z) \vee A(x, f(y), f(z))$$

Problem 4. (15 points)
In this problem, we will represent Tic-Tac-Toe as a planning problem.
(1) Write all actions for "playing" this game. For each "relation" give a (very) short description for what it represents. Clearly state any assumptions you are making.

(2) Represent the state below using the same relations/terminology:
_ | O | X
_ | X | X
_ | _ | O

(3) Give a sequence of actions (ignore the fact that these should be played by different people) that results in X winning. State each action and unification/substitution you are using and the resulting state.

Problem 5. (15 points)
Solve the following planning problem using backwards search (the non-graphplan kind). You mush show all possible branches and substitutions/unifications at each step. You may choose to explore the tree however you want.

Initial: $Class(csci, 4511) \wedge Class(csci, 5211) \wedge Class(math, 4401) \wedge Have(time)$
Goal: $Graduate(college)$

Action: $Study(x, y)$
Preconditions: $Class(x, y) \wedge Have(time)$
Effects: $\neg Have(time) \wedge Prepared(x, y)$

Action: $PassEasy(math, x)$
Preconditions: $Class(math, x) \wedge Prepared(math, x)$
Effects: $Have(time) \wedge Finish(math, x)$

Action: $PassHard(x, y)$
Preconditions: $Class(x, y) \wedge Prepared(x, y)$
Effects: $Finish(x, y)$

Action: $Degree(x, y)$
Preconditions: $Finish(math, x) \wedge Finish(csci, y)$
Effects: $Graduate(college)$

Problem 6. (20 points)
Show 2 layers of graphplan (i.e. 2 action rounds and 3 sets of states) for the following planning problem. Then show a copy of your answer with all muexes between actions clearly shown.

Initial: $\neg Overgrown \wedge \neg Happy \wedge \neg Money$

Action: $MowLawn()$
Precondition:
Effects: $\neg Overgrown \wedge \neg Happy$

Action: $Lawncare()$
Precondition: $Money$
Effects: $\neg Overgrown \wedge \neg Money$

Action: $Relax()$
Precondition:
Effects: $Happy \wedge Overgrown$

Action: $Work()$
Precondition:
Effects: $Money \wedge \neg Happy$