Problem 1. (20 points)
Convert the following sentence to conjunctive normal form (CNF).
\[ \forall x \ (\forall y \ A(x) \land B(y) \iff C(x, y)) \Rightarrow (\exists y \ D(y) \land E(x, y)) \]

Problem 2. (20 points)
Apply resolution on the following KB to determine if: \( KB \models \alpha \)
You must show what variables you are unifying/substituting to make resolution possible between parts/clauses.

KB:
\[
(A(cat) \lor C(x, y)) \land (\neg B(x, y) \lor C(x, y)) \land (\neg A(x) \lor B(hippo, x))
\]

\( \neg \alpha \): (Note: this is already negated)
\[
(\forall x \ \neg B(hippo, x) \lor B(x, F(x))) \land (\forall y \ \neg C(cat, y))
\]

Problem 3. (20 points)
Use backward chaining on the following sentences to determine whether: Exists x Traps(Felicidad,x)

\[
\exists x \ \text{Troll}(x) \\
\forall x \ \text{Troll}(x) \Rightarrow \text{Large}(x) \\
\exists x \ \text{Troll}(x) \land \text{Aggressive}(x) \\
\forall x \ \text{Large}(x) \land \text{Aggressive}(x) \Rightarrow \text{Dangerous}(x) \\
\forall x, y \ \text{Hunter}(x) \land \text{Dangerous}(y) \land \text{Bounty}(y) \Rightarrow \text{Traps}(x, y) \\
\text{Hunter}(\text{Felicidad}) \\
\exists x \ \text{Troll}(x) \land \text{Bounty}(x)
\]
**Problem 4.** (10 points)
Use forward-search to solve the following planning problem. Use a breadth-first-search to approach for searching the space until a goal is found. Show all possible states at the depth the goal was found as well.

Initial = ¬Study ∧ ¬Passed  
Goal = Study ∧ Passed

Action = Cram,  
Precondition:  
Effect: Study

Action = PassTest,  
Precondition: Study  
Effect: ¬Study ∧ Passed

**Problem 5.** (30 points)
Apply graph-plan to the following problem until the mutexes converge (i.e. the mutexes stop changing between levels). **Note:** there was initially an error in action “W” that is fixed now.

Initial: A ∧ ¬B ∧ ¬C

Action( W,  
Preconditions: A  
Effects: ¬B ∧ C)

Action( X,  
Preconditions: C  
Effects: ¬C)

Action( Y,  
Preconditions: A ∧ C  
Effects: ¬A ∧ B)

Action( Z,  
Preconditions: B ∧ ¬C  
Effects: ¬B ∧ C)