1. Propositional **Logic.**

Using the propositional logic inference rules studied in class, show formally (using a proof rather than a truth table) that “A” follows from the “given” sentences shown below. (Don’t deduce more than 10 additional sentences. With each sentence, indicate as “justification” which rule you applied to which sentence(s) to obtain the result.)

Number	**Sentence**	**Justification**
1	$P \wedge Z$	given
2	$(\neg R \wedge \neg W) \vee (\neg P)$	given
3	$(W \wedge Q) \Rightarrow P$	given
4	$Q \vee W$	given
5	$Q \Rightarrow (A \vee P)$	given
6	$(P \wedge Q) \Rightarrow (A \vee R)$	given

2. Convert from English to FOL

Translate the following sentences into first-order logic:

(i) Joe is smart and Jim is not.

(ii) No fish can walk.

(iii) Red mushrooms are poisonous.

(iv) All PCs are either big, or ugly, or both.

(v) Students who attended all lectures find this test easy.

3. Convert FOL to CNF

Every FOL sentence can be converted to a logically equivalent sentence that is in a "normal form" called conjunctive normal form.

Convert the sentence (∀x)(P(x)=>((∀y)(P(y)=>P(f(x,y)))^~(∀y)(Q(x,y)=>P(y))))

4. Resolution in FOL

Problem Statement

Tony, Claude and Ellen belong to the Zymba Club. Every member of the Zymba Club is either a skier or a mountain climber or both. No mountain climber likes rain, and all skiers like snow. Ellen dislikes whatever Tony likes and likes whatever Tony dislikes. Tony likes rain and snow.

We want to answer the following queries:

· Is there a member of the Zymba Club who is a mountain climber but not a skier?

· Who is it?

a. Translate the problem statement into FOL Sentences

b. Convert to Conjunctive Normal Form

c. Produce an answer to the first query using a Resolution

4. Short Answer

a. Given the Prolog program (where tweety is a constant, X a variable, and NOT is Prolog's standard form of negation):

bird(tweety).
fly(X): bird(X), NOT ostrich(X).

Is the fact that tweety flies inferred? Why or why not?

b. What is the most general unifier of [a, [a], [A, b]] and [c, [d], [a, B]], where a, b, c and d are variables and A and B are constants? You need not show your work, just the answer.

c. What is the difference between Entailment, inference and implicature?

d. Name 3 Neat and 3 Scruffy research projects.

6. Multiple Choice Questions

Circle the letter that corresponds to the best answer for the question:

1. Which one of the following is not a literal?
   a. P(x, y, z)
   b. A ∧ B
   c. ¬R(C17, John, Larry)
   d. MoonIsMadeOfGreenCheese

2. Which one of the following is not true of the De Morgan laws?
   a. They are tautologies.
   b. They are useful in when pushing negations down to the level of literals.
   c. They are applicable only in propositional logic.
   d. They are used when converting sentences into conjunctive normal form.

3. Which one of the following is the role of functions in first-order logic?
   a. They allow you to substitute predicates for constants.
   b. They allow you to refer to objects in the domain indirectly via other objects.
   c. They allow you to express conjunctions as disjunctions.
   d. They allow you to change the quantifier scope of a negated existential variable.

4. Which one of the following is not true of ground literals?
   a. They have only universally quantified variables as arguments.
   b. They behave just like propositional symbols in automated reasoning.
   c. They might unify with literals containing only universally quantified variables.
   d. They may contain terms that are functions.

5. What substitutions result from unifying P(x, John, y) with P(Sarah, F(y), z)
   a. These literals fail to unify.
   b. {x/Sarah, John/F(y), y/z}
   c. {x/John, y/Sarah, F/z}
   d. The empty set: { }

6. If C is a constant, x is a variable, and F is a function, which of these will not unify?
   a. x and F(x)
   b. x and C
   c. C and F(x)
   d. F(C) and F(x)

7. Which one of the following is the implication form of a definite clause?
   a. $\neg P(x) \Rightarrow Q(x)$
   b. $K(x) \wedge G(x) \Rightarrow E(x)$
   c. $M(x) \wedge N(x) \Rightarrow O(x) \wedge Q(x)$
   d. $D(x) \wedge E(x) \wedge F(x) \Rightarrow \neg G(x)$

8. Which one of the following clauses can be resolved with Animal(Tuna)?
   a. $\neg$Loves(y, x) $\vee$ $\neg$Animal(z) $\vee$ $\neg$Kills(x, z)
   b. Animal(Curiosity)
   c. Kills(x, y) $\vee$ Animal(y)
   d. $\neg$Kills(Jack, Tuna)

9. Which one of the following is not a means of handling equality in first-order logic?
   a. Paramodulation
   b. Demodulation
   c. Propositionalization of First-Order Sentences
   d. Addition of equality axioms

10. Which one of the following is not a sound inference procedure in first-order logic?
   a. abduction
   b. forward-chaining
   c. backward-chaining
   d. resolution theorem proving