Midterm Examination 2

CSCI 561: Foundations of Artificial Intelligence

Spring 2015

Student ID: _____.

Last Name: _____.

First Name: _____.

USC email: _____.

Instructions:

1. Date: Tuesday 3/31/2015 from 5:05pm – 6:20 pm
2. Maximum credits/points for this midterm: 100 points.
3. Credits/points for each question is indicated before the question.
4. No books (or any other material) are allowed.
5. Write down name, student ID and USC email address.
6. Your exam will be scanned and uploaded online.
7. Do NOT write on the 2D barcode. You could lose all the points for that page!
8. Do NOT write within a 1" margin of the edges of the page. You could lose points if the scanner cuts off the margins slightly.
9. No questions during the exam. If something is unclear to you, write that in your exam.
10. Be brief: a few words are often enough if they are precise and use the correct vocabulary studied in class.
11. When finished raise completed exam sheets until approached by proctor.
12. Adhere to the Academic Integrity code.

Problems	**100 points total**
1. Multiple Choice Questions	10 points
2. True/False Questions	10 points
3. Truth Tables	20 points
4. Propositional Resolution	20 points
5. First-Order Representation	20 points
6. First-Order Inference	20 points

1. Multiple Choice Questions (10 points)

Circle the best choice for each question (1 point each)

1. Which one of the following is a clause?
   a. $\neg P \vee Q \vee \neg R \vee S$
   b. $P(C1, C2) \wedge Q(C3, C4)$
   c. $A \vee B \Rightarrow C \vee D$
   d. $\neg F \wedge G$

2. Which one of the following is not in Conjunctive Normal Form?
   a. $A \wedge B \wedge C \wedge D$
   b. $(\neg P \vee \neg Q) \wedge (Q \vee \neg R \vee \neg S)$
   c. $\neg R(Flour, Salt, Vinegar)$
   d. $P(A) \vee (Q(B) \wedge R(C))$

3. If $\alpha \models \beta$ then which one of the follow is true?
   a. $\alpha \Rightarrow \beta$ is True in every model.
   b. In every model in which α is True, β is false.
   c. The sentence $(\alpha \vee \neg\beta)$ is unsatisfiable.
   d. There is no assignment of truth values to propositions that would make β False.

4. Which one of the following is not true of the Resolution Rule.
   a. It is the basis of the Davis-Putnam algorithm.
   b. It only applies to pairs of clauses.
   c. A lifted version is used for resolution theorem proving in First-Order Logic.
   d. It is applicable when two clauses each contain exactly the same literal.

5. Which one of the following means: “There is someone who is loved by everybody.”?
   a. $\forall x \ \exists y$. Loves(x, y)
   b. $\forall y \ \exists x$. Loves(x, y)
   c. $\exists y \ \forall x$. Loves(x, y)
   d. $\exists x \ \forall y$. Loves(x, y)

6. Which one of the following is not done during propositionalization of first-order logic?
   a. The rules of Universal Instantiation and Existential Instantiation are applied.
   b. Existential variables are replaced with skolem constants.
   c. Functions are replaced with universally quantified variables.
   d. Universally quantified variables are replaced the set of all possible instantiations.

7. Why do these two literals fail to unify? P(x, y, F(z)) and Q(m, n, F(Frank))
   a. Because variables cannot be unified with other variables
   b. Because these literals have different arity
   c. Because the predicates are different.
   d. Because the function symbols are in different scope.

8. What is the result of forward chaining on $M(x, y) \Rightarrow \neg N(F(x), y)$ given M(John, z)?
   a. Nothing. The antecedent fails to unify.
   b. A contradiction: the empty set { }
   c. M(John, z)
   d. $\neg N(F(John), z)$

9. How should you skolemize this sentence: $\forall x$. Car(x) $\Rightarrow$ $\exists y$. EngineOf(y, x) ?
   a. $Car(F(x)) \Rightarrow EngineOf(F(y), F(x))$
   b. $Car(A) \Rightarrow EngineOf(B, A)$
   c. $\forall x$. $Car(x) \Rightarrow EngineOf(F(x), x)$
   d. This sentence cannot be skolemized.

10. Resolve these clauses: $(Animal(F(x)) \vee Loves(G(x), x))$ and $(\neg Loves(u, v) \vee \neg Kills(u, v))$
   a. $(Loves(G(x), x) \vee \neg Loves(u, v))$
   b. $(Animal(F(x)) \vee \neg Kills(G(x), x))$
   c. $(Animal(F(v)) \vee Loves(G(v), v))$
   d. These clauses fail to unify and cannot be resolved.

2. True/False Questions (10 points)

Circle True or False for each question (1 point each)

1. [True/False] Paramodulation is a means of handling equality in first-order logic.

2. [True/False] Abduction is a sound inference procedure in first-order logic.

3. [True/False] A **PartOf** hierarchy allows for an inference process called Inheritance.

4. [True/False] Implicature infers entailed sentences.

5. [True/False] In the debate between Neats vs Scruffies, Doug Lenat's Cyc is Scruffy.

6. [True/False] Knowledge engineering a system, like Mycin, is a simple process, but time consuming.

7. [True/False] The Semantic Web and KQML are examples of knowledge sharing.

8. [True/False] Propositional logic is monotonic.

9. [True/False] Prolog uses both unification and forward chaining.

10. [True/False] The classifier Loom is not complete.

3. Truth Tables (20 points)

a. (18 points) Prove the following using a truth table: $(\neg P \vee Q) \wedge P) \vDash Q$
Draw your table in the space below. There should be one row for each model. There should be columns for each propositional symbol. There should be sufficient number of additional columns to prove entailment.

b. (2 points) Does your table prove the entailment relationship? Explain how one can tell by examining your table.

4. Propositional Resolution (20 points)

a. (10 points) Convert this sentence into conjunctive normal form using only the Distributivity of ∨ over ∧ Rule and the Associativity Rule. Show each application of a rule on a separate line.

1.	(A ∧ B) ∨ (C ∧ D)	Given

b. (10 points) Show that the given set of clauses is unsatisfiable using ONLY the resolution rule. Show each application of the resolution rule on a separate line, and indicate which lines are being resolved by the rule.

1.	(P)	Given
2.	(¬S)	Given
3.	(R ∨ S)	Given
4.	(¬P ∨ Q)	Given
5.	(¬Q ∨ ¬R)	Given

5. First-Order Representation (20 points)

Consider a domain with the following relations and objects.

Color(x, y)	Object x has the color y
On(x, y)	Object x is on top of object y
Expensive(x)	Object x is expensive
Block1, Block2, Block3, Block4	Constants denoting objects
Red, Blue	Constants denoting colors

a. Formalize the following sentences for this domain. (4 points each)
   1. Block2 or block3 is blue.

   2. Everything red is on top of something blue.

   3. Block3 is not on top of any red object.

   4. Block4 has something on top of it, but that thing has nothing on top of it.

b. What ground literals are instantiated when you propositionalize the literal Expensive(x) in this domain? (4 points)

6. First-Order Inference (20 points)

Draw the proof tree that shows a contradiction for the following four clauses, using only the lifted version of the Resolution Rule. Show each clause that is derived from the application of the Resolution Rule, with lines connecting it to the pair of clauses that were resolved. The symbols {w, x, y, z} denote universally quantified variables, and the symbols {A, B, C} denote constants in the domain.