CS 4660: Artificial Intelligence
Spring 2022
Assignment 2
Due 11:59pm February 28th, 2023

Directions: Complete questions 1-5 below. Show your work where applicable. Submit 1 PDF document with your text answers (Typed or Handwritten and Scanned).

1. (10pt) Consider the following sentences.
   a. $((smoke \wedge heat) \rightarrow fire) \Leftrightarrow ((smoke \rightarrow fire) \vee (heat \rightarrow fire))$
      i. (2.5 pt) Show the truth table for this sentence
      ii. (2.5 pt) Is this sentence Valid, Satisfiable, or Neither
   b. $(a_1 \vee a_3) \wedge (\neg a_1 \vee a_2) \wedge (\neg a_1 \vee a_4) \wedge (\neg a_1 \vee \neg a_4) \wedge (\neg a_3)$.
      i. (2.5 pt) Show the truth table for this sentence
      ii. (2.5 pt) Is this sentence Valid, Satisfiable, or Neither

2. (20 pt) Represent the following sentences in first-order logic, using a consistent vocabulary (which you must define as well).
  a. (1pt) Define the vocabulary. **For example**, you might have:
      i. Buys(X,Y,Z) = Person X buys Item Y from Person Z
      ii. W > Score(X,Y,Z) = W is larger than score Person X gets in course Y during semester Z
      iii. Predicates: Person(X), Clever(Y), Politician(Z)
      It may make more sense to do question a. last.
  b. (1pt) Every person who buys a policy is clever.
  c. (1pt) No person buys an expensive policy.
  d. (1pt) There is a barber who shaves all men in town who do not shave themselves.
  e. (1pt) A person born in the UK, each of whose parents is a UK citizen or a UK resident, is a UK citizen by birth.
  f. (1pt) A person born outside the UK, one of whose parents is a UK citizen by birth, is a UK citizen by descent.
  g. (1pt) Politicians can fool some of the people all of the time, and they can fool all of the people some of the time, but they can't fool all of the people all of the time.
  h. (1pt) Some students took Russian in spring 2001.
  i. (1pt) Only one student took German in spring 2001.
  j. (1pt) The best score in German is always higher than the best score in Russian.

3. (10 pt) Attempt to unify the following pairs of expressions. Either show their most general unifiers, or explain why they will not unify. Use the {a/b} substitution form. Upper case letters are variables, lowercase are constants. Assume all variables are universally instantiated.
  a. (2 pt) p(X, a, Y) and p(Z, Z, b)
  b. (2 pt) p(X, X)   and p(a, b)
  c. (2 pt) p(X, Y, Z) and p(c,d,d)
  d. (2 pt) ancestor(X, father(X)) and ancestor(david, george)
  e. (2 pt) p(a, X) and p(Y, Z)

4. (30 pt) Consider the following knowledge base
    a. Prove that Q is true with:
        1. P → Q
        2. L ∧ M → P
        3. B ∧ L → M
        4. A ∧ P → L
        5. A ∧ B → L
        6. A
        7. B
        i. (4 pt) Forward-Chaining
        ii. (4 pt) Backward-Chaining
        iii. (4 pt) Resolution

    b. Prove t → s:
        1. p → q
        2. [q ∧ r] → s
        3. [t ∧ u] → r
        4. u → w
        5. t → y
        6. y → u
        7. r → p
        8. p → m
        i. (3 pt) Express in clause form
        ii. (5 pt) Forward-Chaining
        iii. (5 pt) Backward-Chaining
        iv. (5 pt) Resolution

5. (40 pt) Consider the following stories:
   a. "All dogs who are not tired and are smart are happy. Those dogs who do tricks are not stupid. Fido can do tricks and is full of energy. Happy dogs have exciting lives."
      i. (2.5 pt) Translate the sentences of into predicate form
      ii. (2.5 pt) Transform the predicate sentences into clause form
      iii. (5 pt) Prove via forward chaining that Fido has an exciting life
      iv. (5 pt) Prove via backward chaining that Fido has an exciting life
      v. (5 pt) Prove via Resolution that Fido has an exciting life

   b. "Anyone passing the history exams and winning the lottery is happy. But anyone who studies or is lucky can pass all the exams. John did not study, but he is lucky. Anyone who is lucky wins the lottery."
      i. (2.5 pt) Translate the sentences of into predicate form
      ii. (2.5 pt) Transform the predicate sentences into clause form
      iii. (5 pt) Prove via forward chaining that John is happy.
      iv. (5 pt) Prove via backward chaining that John is happy
      v. (5 pt) Prove via Resolution that John is happy