### Course: CS420 - Artificial Intelligence

04 – Inference with PL and FOL

**Question 1.** Given a knowledge base KB as follows, {**P R**, **¬S P**, **¬S**, **R Q**}. Consider the pseudo-code function PL-RESOLUTION given in the lecture to check whether **KB entails Q**.

Present your work to the table below, in which the first column contains KB ∧ ¬α in CNF, and every of the next columns includes new sentences added to KB after each loop. Note that

* Duplicated sentences are omitted from the table
* *Circle the unit clauses that lead to the contradiction and hence the function ends successfully, if possible*
* Process the clauses in order, that is first pair clause 1 with clause 2, 3, 4… then pair clause 2 with clause 3, 4…, and so on.

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| --- | --- | --- | --- | --- |
| CNF sentences | Loop 1 | Loop 2 | Loop 3 | Loop 4 |
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**Circle the correct option**, IS or IS NOT.

Following the result of resolution, the sentence Q **IS / IS NOT** entailed by KB.

**Question 2.** Repeat Question 1. but this time you check whether **KB entails ¬Q**.

**Question 3.** Are the above problems solved by using Forward chaining or Backward chaining? Give your reason.

**Question 4.** Consider the following text. “*Heather attended the meeting* or Heather was not invited. If *the boss wanted Heather at the meeting*, then *she was invited*. Heather did not attend the meeting. If the boss did not want Heather there, and the boss did not invite her there, then *she is going to be fired*.”

Use resolution to prove that **Heather is going to be fired**.*Hint: clauses in italic are good candidates for propositions.*

Let each of the following propositions denote the facts represented in the corresponding clause.

* Proposition A represents for “Heather attended the meeting.”

Then the propositional KB in CNF will be



Apply resolution to KB ∧ ¬α

1. Negation of conclusion
2. from sentences and
3. from sentences and
4. from sentences and
5. • from sentences and

Conclusion: Therefore, Heather is going to be fired

**Question 5.** Consider the following knowledge base of definite clauses.

1. C ∧ D → Y
2. R ∧ Z → C
3. ¬B ∨ D
4. ¬D ∨ ¬R ∨ Z
5. B
6. R → D
7. D → R

Prove **Y** using backward chaining and forward chaining. In forward chaining, we only trigger a rule once for simplicity.

**Question 6.** Convert the following English sentences into FOL sentences, using only the predicates given inside the square brackets.

1. All green apples are sour. [Green1, Apple1, Sour1]

1. All babies love some green apples. [Baby1, Loves2, Apple1, Green1]

1. Some babies do not love any sour apple. [Baby1, Loves2, Apple1, Sour1]

1. Mary eats only one apple. [Apple1, Eat2]

**Question 7.** Find (if it were possible) the MGU for each of the following pairs of FOL statements. Note that uppercase letters represent constants, while lowercase ones denote varibles, predicate/function names.

1. P( g(h(x)) , f(g(h(B))) , f(x) ) and P( y , f(y), z)
2. P( g(h(x)) , f(h(y)) , y ) and P( g(z) , f(z) , h(A) )
3. P( x , h(B) , h(x) ) and P( f(g(y)) , y , h(f(g(h(A)))) )
4. P( x , g(x) , z ) and P( f(y) , g(f(B)) , h(y) )
5. P( f(g(x)) , g(B) , h(x) ) and P( f(y) , y , h(C) )
6. P( x , h(x) , h(y) ) and P( f(g(z)) , h(f(g(B))) , h(z) )

**Question 8.** Consider the following KB.

|  |
| --- |
| 1. Buffalo(x) ∧ Pig(y) → Faster(x,y) 4. Buffalo(Bob)  2. Pig(y) ∧ Slug(z) → Faster (y,z) 5. Pig(Pat)  3. Faster(x,y) ∧ Faster (y, z) → Faster(x, z) 6. Slug(Steve) |

Use forward chaining in first-order logic to prove **Faster(Bob, Steve)**. If several rules apply, use the one with the smallest number. Do not forget to indicate the unification at every step.

From sentence and sentence infer (1) θ = { }

From sentence and sentence infer (2) θ = { }

**Question 9.** Consider the following text. *“Anyone passing his history exams and winning the lottery is happy. But anyone who studies or is lucky can pass all his exams. John did not study but John is lucky. Anyone who is lucky wins the lottery.”*

1. For each of the axiom above, write the FOL sentence that best expresses its intended meaning, using only the following predicates

PASS(x, y): “x passes the y exam” HAPPY(x): “x is happy” LUCKY(x): “x is lucky”

STUDY(x): “x studies” WINLOT(x): “x wins the lottery”

5. Convert the above FOL clauses to clausal form





12. Use resolution to answer the question “Is John happy?”
13. Negation of conclusion
14. from and θ = { }
15. from and θ = { }
16. from and θ = { }
17. from and θ = { }
18. • from and θ = { }

Conclusion: