National University

Of Computer & Emerging Sciences Faisalabad-Chiniot Campus

Artificial Intelligence **Course Instructor** **Ms. Mahzaib Younas**		
Time allowed = 30 min	**Quiz 5**	**Total Marks = 30**

BCS Section E

Roll No	**Name**	**Signature**

Question No 01: For each question statement below, choose the correct option.[6]

1. Which rule is equal to the resolution rule of first-order clauses?	**2. What is meant by factoring?**
a) Propositional resolution rule b) Inference rule c) Resolution rule d) None of the mentioned	a) Removal of redundant variable b) Removal of redundant literal c) Addition of redundant literal d) Addition of redundant variable
3. What will happen if two literals are identical?	**4. The statement comprising the limitations of FOL is/are ____________**
a) Remains the same b) Added as three c) Reduced to one d) None of the mentioned	a) Expressiveness b) Formalizing Natural Languages c) Many-sorted Logic d) All of the mentioned
5. Which are more suitable normal form to be used with definite clause?	**6. Translate the following statement into FOL. "For every a, if a is a philosopher, then a is a scholar"**
a) Positive literal b) Negative literal c) Generalized modus ponens d) Neutral literal	a) ∀ a philosopher(a) scholar(a) b) ∃ a philosopher(a) scholar(a) c) All of the mentioned d) None of the mentioned

Question No 02: Translate the following English sentences into first-order logic formulas: [6]

a) Every student takes at least one course.
$\forall x\ (Student(x) \Rightarrow \exists y\ (Course(y) \land Takes(x,y)))$
b) Every student who takes Analysis also takes Geometry.
$\forall x\ (Student(x) \land Takes(x,Analysis) \Rightarrow Takes(x,Geometry))$

c) No student failed Chemistry but at least one student failed History

$(\neg\exists s(Student(s) \wedge Failed(s, Chemistry))) \wedge (\exists x(Student(x) \wedge Failed(x, History)))$

Question No 03: Apply the unification **[6 Marks]**

a- {Q(a, g(x,a), f(y)); Q((a), g(f(b),a), x)}
{Q(a, g(x,a), f(y)); Q((a), g(f(b),a), x)} , subst(x/f(b)
{Q(a, g(f(b),a), f(y)); Q((a), g(f(b),a), f(b))}, subs(y/b)
{Q(a, g(f(b),a), f(b)); Q((a), g(f(b),a), f(b))}
Successfully unified.

b- {p (b, X, f(g(Z))); and p(Z,f(Y), f(y))}
{p (b, X, f(g(b))); and p(b,f(Y), f(y))} sub(Z/b)
{p (b, f(Y), f(g(b))); and p(b,f(Y), f(y))} sub(X,f(y))
{p (b, f(g(b)), f(g(b)); and p(b,f(g(b)), f(g(b)))} sub(Y/g(b))

Unified successfully.

Question No 03: Consider the following axioms: **[12 Marks]**

1. All hounds howl at night.
2. Anyone who has any cats then anyone will not have any mice. **(Hint : after then statement used with the negation of Quantifiers)**
3. Light sleepers do not have anything which howls at night.
4. John has either a cat or a hound.
5. (Conclusion) If John is a light sleeper, then John does not have any mice.

The conclusion can be proved using Resolution as shown below. The first step is to write each axiom as a well-formed formula in first-order predicate calculus. The clauses written for the above axioms are shown below, using LS(x) for `light sleeper'.

Part 1: Make the FOL statements for each above Statement; **[4 Marks]**

1. $\forall x\ (HOUND(x) \rightarrow HOWL(x))$
2. $\forall x\ \forall y\ (HAVE\ (x,y) \wedge CAT\ (y) \rightarrow \neg\ \exists z\ (HAVE(x,z) \wedge MOUSE\ (z)))$
3. $\forall x\ (LS(x) \rightarrow \neg\ \exists y\ (HAVE\ (x,y) \wedge HOWL(y)))$
4. $\exists x\ (HAVE\ (John,x) \wedge (CAT(x) \vee HOUND(x)))$
5. $LS(John) \rightarrow \neg\ \exists z\ (HAVE(John,z) \wedge MOUSE(z))$

Part 2: Drop the universal and existential quantifiers of each statement. **[2 Marks]**

1. $\forall x\ (HOUND(x) \rightarrow HOWL(x))$

   $\neg\ HOUND(x) \lor HOWL(x)$

2. $\forall x\ \forall y\ (HAVE\ (x,y) \land CAT\ (y) \rightarrow \neg\ \exists z\ (HAVE(x,z) \land MOUSE\ (z)))$

   $\forall x\ \forall y\ (HAVE\ (x,y) \land CAT\ (y) \rightarrow \forall z\ \neg\ (HAVE(x,z) \land MOUSE\ (z)))$

   $\forall x\ \forall y\ \forall z\ (\neg\ (HAVE\ (x,y) \land CAT\ (y)) \lor \neg\ (HAVE(x,z) \land MOUSE\ (z)))$

   $\neg\ HAVE(x,y) \lor \neg\ CAT(y) \lor \neg\ HAVE(x,z) \lor \neg\ MOUSE(z)$

3. $\forall x\ (LS(x) \rightarrow \neg\ \exists y\ (HAVE\ (x,y) \land HOWL(y)))$

   $\forall x\ (LS(x) \rightarrow \forall y\ \neg\ (HAVE\ (x,y) \land HOWL(y)))$

   $\forall x\ \forall y\ (LS(x) \rightarrow \neg\ HAVE(x,y) \lor \neg\ HOWL(y))$

   $\forall x\ \forall y\ (\neg\ LS(x) \lor \neg\ HAVE(x,y) \lor \neg\ HOWL(y))$

   $\neg\ LS(x) \lor \neg\ HAVE(x,y) \lor \neg\ HOWL(y)$

4. $\exists x\ (HAVE\ (John,x) \land (CAT(x) \lor HOUND(x)))$

   $HAVE(John,a) \land (CAT(a) \lor HOUND(a))$

5. $\neg\ [LS(John) \rightarrow \neg\ \exists z\ (HAVE(John,z) \land MOUSE(z))]$ *(negated conclusion)*

   $\neg\ [\neg\ LS\ (John) \lor \neg\ \exists z\ (HAVE\ (John,\ z) \land MOUSE(z))]$

   $LS(John) \land \exists z\ (HAVE(John,\ z) \land MOUSE(z)))$

   $LS(John) \land HAVE(John,b) \land MOUSE(b)$

Part 3: Apply the resolution theorem and draw the conclusion. **[6 Marks]**

Set of CNF Clauses

1. $\neg\ HOUND(x) \lor HOWL(x)$
2. $\neg\ HAVE(x,y) \lor \neg\ CAT(y) \lor \neg\ HAVE(x,z) \lor \neg\ MOUSE(z)$
3. $\neg\ LS(x) \lor \neg\ HAVE(x,y) \lor \neg\ HOWL(y)$
4.
   1. $HAVE(John,a)$
   2. $CAT(a) \lor HOUND(a)$
5.
   1. $LS(John)$
   2. $HAVE(John,b)$
   3. $MOUSE(b)$

Resolution:

[1.,4.(b):] 6. $CAT(a) \lor HOWL(a)$
[2,5.(c):] 7. $\neg HAVE(x,y) \lor \neg CAT(y) \lor \neg HAVE(x,b)$
[7,5.(b):] 8. $\neg HAVE(John,y) \lor \neg CAT(y)$
[6,8:] 9. $\neg HAVE(John,a) \lor HOWL(a)$
[4.(a),9:] 10. $HOWL(a)$
[3,10:] 11. $\neg LS(x) \lor \neg HAVE(x,a)$
[4.(a),11:] 12. $\neg LS(John)$
[5.(a),12:] 13. $\square$