Write your answers on these pages and show your work. If you feel that a question is not fully specified, state any assumptions you need to make in order to solve the problem. You may use the backs of these sheets for scratch work.

Write your name on this and all other pages of this exam. Make sure your exam contains four problems on eight pages.

Name

Student ID

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PROBLEM 1 - First-Order Predicate Calculus (35 points)

a) Give one (1) predicate calculus representation for each of these English sentences. If you feel a sentence is ambiguous, provide a more detailed sentence that better captures the version represented by your FOPC. Choose reasonable constants, predicates and functions - the predicate dogs-chase-cats is not an acceptable answer to the first question.

i) Dogs chase cats.

ii) Some computers are cheap.

iii) Every book is valuable.

iv) Some chess pieces move diagonally, or my name isn’t Bobby Fischer.

v) All pianists and conductors know a piece written by Mozart.
b) For the English-FOPC pairs below, provide an interpretation that shows that the FOPC on the right does not represent the English on the left. Briefly explain your answers.

i) All movie stars are envied. \[ \forall X \{ \text{movie\_star}(X) \land \text{envied}(X) \} \]

ii) All children, when healthy, like ice cream. \[ \forall X \{ \text{child}(X) \rightarrow \text{healthy}(X) \lor \neg \text{likes}(X, \text{ice\_cream}) \} \]
PROBLEM 2 - Other Forms of Knowledge Representation (20 points)

a) Draw a simple ISA hierarchy that (partially) represents the classes offered at the University of Wisconsin - Madison. Do not, of course, draw the entire hierarchy, but do meet the following constraints:

- your hierarchy must be at least three (3) levels deep,
- your hierarchy must contain at least one (1) inheritable property
- your hierarchy must contain at least one (1) overridden default
b) Represent the following in *conceptual dependency*.

i) *Ali punched Frazier.*

ii) *Bill told Sue that Mary told John to visit Sue.*
PROBLEM 3 - Deduction (30 points)
a) Use binary resolution to solve the problem below.

GIVEN:
(1) \( \forall X [ p(X) \rightarrow q(X) ] \)
(2) \( \forall X [ p(X) \rightarrow [ \exists Y w(Y) ] ] \)
(3) \( \forall X \forall Y [ [ q(X) \land w(Y) ] \rightarrow s(X) ] \)
(4) \( p(\text{mary}) \)

SHOW: \( s(\text{mary}) \)

The givens in clausal form:

The negated query in clausal form:

The resolution proof:

(over)
b) Show how putting FOPC wff’s in clausal form and then doing binary resolution can produce the same new wff as the following natural deduction inference rules produce. You can show this by producing one concrete example, using P’s and Q’s, for each case; you do not have to show this for the general case.

i) modus tollens

ii) and elimination
PROBLEM 4 - Common Lisp (15 points)

Write a car-cdr recursive Common Lisp function `(contained-in? item sexpr)`. This function should return non-nil (i.e., "true") if `item` is anywhere in `sexpr`. For example,

```lisp
> (contained-in? 3 '(1 2 3 4 5))
  t ;;; actually, anything other than NIL is an acceptable result

> (contained-in? '(a b) '(a b (c d) (a) (b)))
  nil

> (contained-in? '(a b) '(1 2 (((a b) c)) 6))
  t

> (contained-in? '(a b) '(a b))
  t
```

```lisp
(defun contained-in? (item sexpr)
  "Is ITEM contained anywhere in SEXP?"
)`