Computer Science Department
Stanford University
Comprehensive Examination in Artificial Intelligence
Autumn 1995

October 17, 1995

READ THIS FIRST!

1. You should write your answers for this part of the Comprehensive Examination in a BLUE BOOK. Be sure to write your MAGIC NUMBER on the cover of every blue book that you use.

2. Be sure you have all the pages of this exam. There are 2 pages.

3. This exam is OPEN BOOK. You may use notes, articles, or books—but no help from other sentient agents such as other humans or robots.

4. Show your work, since PARTIAL CREDIT will be given for incomplete answers. For example, you can get credit for making a reasonable start on a problem even if the idea doesn't work out; you can also get credit for realizing that certain approaches are incorrect. On a true/false question, you might get partial credit for explaining why *you* think something is true when *we* think it is actually false. But no partial credit can be given if you write nothing.

6

1. Frame Representations **[18 points]**

Consider the knowledge base below represented in a frame language. The frame language represents monotonic knowledge by describing classes, members of classes, subclass relations, slot values that apply to all members of a class, and value restrictions on slots that constrain values of the slot to be members of a given class.

```
CompanyVehicle                          ; The class of vehicles owned by
    SubclassOf: Vehicle                 ; a corporation.
    Owner
        Value_Restriction: Corporation

CompanyCar                              ; The class of company vehicles
    SubclassOf: CompanyVehicle          ; that are sedans.
    Style: Sedan

Envig's_Car                             ; Envig's car.
    MemberOf: CompanyCar
    Owner: Envig
```

(a) What is the style of Envig's car? [2 points]

(b) What class is Envig a member of? [2 points]

(c) Represent in predicate logic the information in these frames using the following relations: [4 points]

```
(Subclass <class1> <class2>)        ; <class1> is a subclass of <class2>.
(Member <object> <class>)           ; <object> is a member of <class>.
(MemberValue <value> <slot> <class>)
        ; <value> is a value of <slot> in <class>.
(OwnValue <value> <slot> <object>)
        ; <value> is a value of <slot> in <object>.
(ValueRestriction <class1> <slot> <class2>)
        ; <class1> is a value restriction for <slot> in <class2>.
```

(d) State any additional axioms describing properties of the relations listed above that would be needed in order to derive the answers to questions (a) and (b). [10 points]

2. Adversary Search **[22 points]**

Suppose that you are using alpha-beta pruning to determine the value of a move in a game tree, and that you have decided that a particular node n and its children can be pruned. If the game tree is in fact a graph and there is another path to the node n, are you still justified in pruning this node? Either prove that you are or construct an example that shows that you cannot.

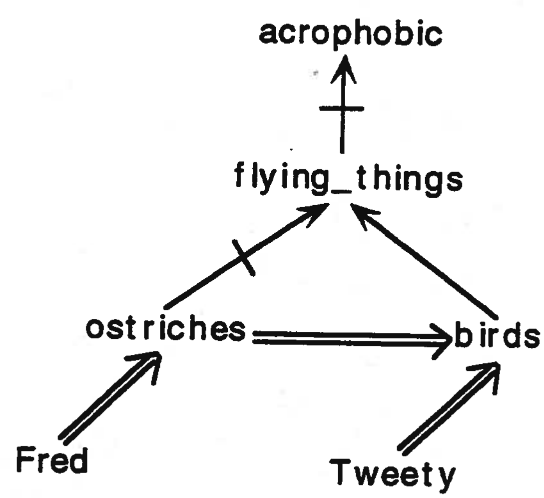
3. First-Order Logic [18 points]

Express the following sentences in clause normal form:

> You can fool some of the people all of the time, but you can't fool all of the people all of the time.

4. Nonmonotonic Reasoning [22 points]

Consider the default theory below represented as a diagram. The notation in the diagram is as follows. Arrows indicate default implications (e.g., Birds are by default flying things), arrows with a line through them indicate default implications in which the conclusion has been negated (e.g., Ostriches are by default not flying things), and double lines indicate nondefault implications (e.g., Fred is an ostrich).



(a) Is the statement that Tweety is not acrophobic a brave consequence of this default theory? Is it a cautious consequence? [6 points]

(b) Is the statement that Fred is not acrophobic a consequence of this theory? [6 points]

(c) Is the statement that Fred is acrophobic a consequence of this theory? [6 points]

(d) Is it correct to say that the brave but not cautious consequences of a default theory are those for which there are arguments both for and against? What would be a more appropriate description? [4 points]

5. Probability [20 points]

Prove that $pr(p \mid q) \leq pr(q \rightarrow p)$.

(8)