UNIVERSITY OF BRISTOL
DEPARTMENT OF COMPUTER SCIENCE

Examination for the Degrees of
BSc, BEng, BA, Meng and MSc

MAY/JUNE 1999 2 Hours

COMS 30106

ARTIFICIAL INTELLIGENCE
3/4a & MSc

This paper contains *FOUR* questions.
The best *THREE* answers will be used for assessment.

Q1 Logic and incomplete information

Given is the following set of clauses *P*:

```
knows(T,S):-student_of(S,T).
knows(X,Y):-friend_of(Y,X).
knows(X,Y):-friend_of(Z,X),knows(Z,Y).
student_of(paul,peter).
friend_of(peter,jan).
```

a) Draw the SLD-tree for the query `?-knows(X,paul)`, and list the answers in the order they are found by Prolog.

[4 marks]

b) Find, by means of resolution-refutation, somebody who knows both Peter and Paul.

[4 marks]

c) Determine *CWA*(*C*), restricted to the predicate `knows`.

[4 marks]

d) Determine *Comp(P)*.

[4 marks]

e) Give three abductive explanations of the observation `knows(jan,maria)`.

[4 marks]

Q2 Search

Given is the following problem. There are two jugs of 7 and 5 litres, initially empty, and an unlimited supply of water. There are three ways to change the amount of water in a jug:

1. a jug can be filled completely;
2. a jug can be emptied completely;
3. water can be poured from one jug into the other, until one jug is empty or the other is full.

a) Sketch part of the search space, starting from the initial situation (0,0) (two empty jugs) and at least containing the situation (0,2) (i.e. large jug is empty, small jug contains 2 litres of water).

[4 marks]

cont.

b) Suppose you are searching for a way to reach a certain situation, such as (0,4). Discuss **briefly** for each of the following search strategies to what extent it is suitable for solving the given problem:

1. depth-first;
2. breadth-first;
3. depth-bounded search;
4. iterative deepening;
5. best-first.

[6 marks]

c) A certain search algorithm finds the following solution for reaching (0,4) first:

(0,0) — (0,5) — (5,0) — (5,5) — (7,3) — (0,3) — (3,0) — (3,5) — (7,1)
— (0,1) — (1,0) — (1,5) — (6,0) — (6,5) — (7,4) — (0,4)

Which search strategy can be applied here? Justify your answer.

[6 marks]

d) The following Prolog clauses represent part of the search space.

```
arc(s(X,Y),s(7,Y)):-X<7.
arc(s(X,Y),s(X,5)):-Y<5.
arc(s(U,V),s(0,Y)):-U>0,Y is U+V,Y=<5.
arc(s(U,V),s(X,0)):-V>0,X is U+V,X=<7.
```

Give the remaining 4 clauses.

[4 marks]

Q3 Natural language

Given is the following Definite Clause Grammar:

```
s              -->   n1(N),vp(N).
vp(N)          -->   iv(N),c.
vp(N)          -->   tv(N),np.
c              -->   [like],np.
np             -->   art,n2.

n1(singular)   -->   [fruit].
n1(plural)     -->   [fruit,flies].
iv(singular)   -->   [flies].
tv(plural)     -->   [like].
art            -->   [a].
n2             -->   [banana].
```

a) Draw the search space belonging to a top-down parse of the sentence ‘fruit flies like a banana’.

[6 marks]

cont.

b) Draw both parse trees for this sentence.

[4 marks]

c) Consider the following heuristic: $h(s)$ = the number of non-terminals in partially parsed sentence s.

Which parse tree is found first if best-first search with depth-count $g(s)$ is applied, i.e. an A algorithm? Motivate your answer.

[4 marks]

d) Is this heuristic optimistic and/or monotonic for an arbitrary DCG? Justify your answer.

[6 marks]

Q4. Inductive reasoning

Given are the following three clauses:

```
p([P|Q]):-p(Q).
p([U,V|W]):-p([V|W]).
p([X,Y|Z]):-p(Z).
```

a) Determine all pairs of clauses C_1, C_2 such that C_1 is more general than C_2 under θ-subsumption.

[4 marks]

b) Determine all pairs of clauses C_1, C_2 such that C_1 is more general than C_2 under logical consequence.

[4 marks]

c) Determine the θ-LGG of the following two clauses:

```
r(c,[a,b,c],[a,b]):-r(c,[b,c],[b]).
r(2,[1,2],[1]):-r(2,[2],[]).
```

[4 marks]

d) Give two specialisations of the clause `e(X,[Y|Z]).`

[4 marks]

b) Describe briefly the difference between bottom-up and top-down induction.

[4 marks]