UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

B. Sc. Examination 2003

COMPUTING AND INFORMATION SYSTEMS

IS53001A (CIS310) Artificial Intelligence

Duration: 2 **hours** 15 **minutes**

Date and time:

Do not attempt more than FOUR questions on this paper.
Full marks will be awarded for complete answers to FOUR questions.
No calculators should be used.

THIS EXAMINATION PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

Question 1 **Search and Problem Solving**

(a) Explain the terms *complete* and *optimal* with regard to search strategies. Why might we prefer to use a strategy which is neither optimal nor complete?

[6]

(b) What are the constraints on the evaluation functions of A* for it to be complete and optimal?

[4]

(c) The following table shows the (fictitious) distances between a number of towns.

From	**To**	**Distance**
Smalltown	Midway	5
Smalltown	Buffalo	15
Smalltown	Clarkville	8
Midway	Albany	5
Albany	Buffalo	4
Albany	Gotham	11
Buffalo	Gotham	5
Clarkville	Delaware	10
Delaware	Exeter	5

Draw a diagram representing this information and show how a path from **Smalltown** to **Gotham** would be calculated by each of

(i) depth-first search

(ii) breadth-first search

(iii) uniform-cost search

[15]

Question 2 **Knowledge Representation and Planning**

(a) (i) In the context of planning, what is meant by the STRIPS assumption and what is the general problem which it addresses?

(ii) Explain the distinction between *linear* and *non-linear planning*.

(iii) Give an example of a problem in the blocks-world domain which requires non-linear planning for an efficient solution, and explain why this is the case.

[7]

(b) (i) Explain what is meant by *monotonicity* and *transitivity* of inference.

(ii) Give an example of an inference using abduction and explain whether this is monotonic or non-monotonic.

[6]

(c) Suppose you are developing an expert system which will give dietary advice. Construct a frame-based semantic network encoding the following information.

- Animal foods are typically sources of protein and fat. Animal foods do not contain fibre.
- Vegetable foods are sources of fibre and carbohydrates.
- Fatty foods include vegetable oils, butter, nuts, bacon and lamb.
- Low-fat foods include most vegetables and poultry.
- Milk contains carbohydrates.
- Nuts and pulses are vegetable sources of protein.
- Calcium is obtained from green leafy vegetables, dairy products (e.g. milk, butter, cheese) and chick-peas (a kind of pulse).

[12]

Question 3 **Formal Logic**

(a) Explain what is meant by *soundness* and *completeness* of a logic, with particular reference to Propositional Logic.

[4]

(b) Show using truth tables whether the following propositions are equivalent:

$$(p \vee q) \rightarrow r, \ (p \rightarrow r) \vee (q \rightarrow r)$$

[4]

(c) Using just the propositional letters p and q and the symbols $\neg$ and $\wedge$, construct formulas which are equivalent to the following:

(i) $p \rightarrow q$

(ii) $p \vee q$

[4]

(d) Express the following statements as formulas of Predicate Calculus. Construct two different versions of each formula, one using only the universal quantifier '$\forall$' and one using only the existential quantifier '$\exists$' (plus any necessary Boolean operators).

(i) Some bird flies

(ii) Not only fish swim.

(iii) If a mammal is not a biped it is a quadruped

[8]

(e) Given the premises *some bird flies* and *no fish flies*, prove using semantic tableau (or other proof-theoretic method) that *some bird is not a fish*. (You will first need to express all the propositions in Predicate Calculus.)

[5]

Question 4 **Natural Language**

A natural language system has the following grammatical and lexical rules:

s	$\longrightarrow$	np vp	det	$\longrightarrow$	[the]
s	$\longrightarrow$	np vp adv	det	$\longrightarrow$	[a]
np	$\longrightarrow$	det n′	n	$\longrightarrow$	[cat]
n′	$\longrightarrow$	adj n	n	$\longrightarrow$	[dog]
n′	$\longrightarrow$	n	tv	$\longrightarrow$	[saw]
vp	$\longrightarrow$	vp adv	tv	$\longrightarrow$	[chased]
vp	$\longrightarrow$	tv np	iv	$\longrightarrow$	[barked]
vp	$\longrightarrow$	iv	adj	$\longrightarrow$	[white]
			adj	$\longrightarrow$	[black]
			adj	$\longrightarrow$	[big]
			adv	$\longrightarrow$	[angrily]

(a) Using the above grammar, draw as many syntax trees as you can (if any) for the sentences:

(i) The black dog barked angrily.

(ii) The big dog chased a white cat.

(iii) The big black dog chased a cat.

[5]

(b) Modify the above grammar so that it will generate the unstarred examples below but not the starred (*) one:

(i) The big black ugly dog chased the small light brown cat.

(ii) The dog is black.

(iii) The dog is light brown.

(iv) * The dog is big black.

[10]

(c) Show how we can use the lambda-calculus to translate the sentence *Every dog barked* into a formula of the first-order predicate calculus, on the basis of a syntax tree for the sentence.

[4]

(d) Describe three actual or potential AI applications using natural language technology.

[6]

Question 5 **Philosophy of AI**

(a) Alan Turing wrote in 1950 that: "at the end of the [20th] century the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted".

(i) What were Turing's grounds for this prediction? [9]

(ii) In view of your knowledge of AI technology, do you think this prediction has been proved correct? How significant is this? [9]

(b) Discuss the following statement with reference to issues in Artificial Intelligence: "No-one supposes that a computer simulation of a storm will leave us all wet. Why would anyone suppose that a computer simulation of mental processes actually has mental processes?" John Searle (1980).

[7]