UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

B. Sc. Examination 2002

COMPUTING AND INFORMATION SYSTEMS

IS53001A (CIS310) Artificial Intelligence

Duration: 2 hours 15 minutes

Date and time:

Answer FOUR questions.
Full marks will be awarded for complete answers to FOUR questions.
There are 100 marks available on this paper.
No calculators should be used.

THIS EXAMINATION PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

Question 1 **Search and Problem Solving**

(a) (i) Explain the difference between *informed* and *uninformed* search.

[3]

(ii) Explain the terms *optimal* and *complete* with regard to search strategies.

[2]

(iii) Compare the following search strategies in terms of completeness, optimality and space complexity: *breadth-first*, *depth-first* and *iterative deepening*.

[5]

(b) A snake-charmer is travelling to a fair carrying a snake, a mongoose and a sack of eggs to feed the snake. To get there he has to cross a river in a boat which will only carry himself and one of the three items. At no time can he leave the snake and the mongoose together as the mongoose might kill the snake. Nor may he leave the snake and the eggs unaccompanied in case it eats them all up.

(i) Describe a suitable representation for the locations of the snake-charmer and his three possessions at any time during the sequence of operations.

(ii) Using this representation, specify the illegal states, i.e.those states which may *not* occur in a solution path.

(iii) What is the minimum number of times the snake-charmer must cross the river in order to safely transport the snake, the mongoose and the sack of eggs? List the intermediate states on the shortest path between the initial state and the goal state.

[15]

Question 2 **Knowledge Representation and Planning**

(a) (i) Explain the terms *forward-chaining* and *backward chaining*. Suppose the following is part of the specification for a central heating system:

> "During business hours the heating comes on if the room temperature drops below 20 degrees C. At other times the heating comes on if the temperature falls below 10 degrees C. Business hours run from 08.00 to 18.00, Mondays to Fridays. [Ignore public holidays] "

Encode this information as a set of production rules using the connectives *if*, *and*, *or*, *then*. Show how the rules would be invoked to decide to turn on the heating assuming the temperature is 16 degrees at 17.00 on a Friday using backward chaining.

[8]

(ii) In the context of knowledge representation what is meant by the terms *frames* and *inheritance*?

Suppose the following information is encoded in a frame-based semantic network:

- President Milhouse is a Republican.
- President Milhouse is a Quaker.
- Quakers are pacifists.
- Republicans are not pacifists.

What problem might be encountered when processing queries about President Milhouse? Suggest how the inheritance mechanism could be restricted to avoid this problem.

[7]

(b) (i) Specify the STRIPS-style planning operation needed to get from the *initial state* to the *successor state* in the following description:

Initial state on(b,c), clear(a), on(a,b), ontable(c)
Successor state on(b,c),clear(a), clear(b), ontable(a), ontable(c)

[5]

(ii) In the above description, how would the planner know whether block c is clear in the initial state?

[2]

(iii) In the context of planning, what is meant by the *frame problem* and how is it dealt with in STRIPS-style planners?

[3]

Question 3 **Formal Logic**

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

[2]

(b) Using truth tables, show whether the following statements of Propositional Logic are equivalent: $\neg p \wedge \neg q$, $\neg(p \vee q)$

[4]

(c) Using semantic tableau (or other proof-theoretic technique) prove that

(i) $\neg(p \wedge q)$ is a theorem of
$p \rightarrow (q \rightarrow r)$ and $\neg\ r$.

(ii) $\exists x Hx$ is a theorem of
$\forall x((Fx \wedge Gx) \rightarrow Hx)$, $\forall x(Ix \rightarrow Gx)$ and $\exists x(Fx \wedge Ix)$.

[9]

(d) Represent the following sentences within Predicate Calculus, stating the intended interpretation of any predicates and constants that you use.

(i) Only birds are feathered and fly.

(ii) Anything that swims is not a bird.

(iii) Some albatrosses are larger than any eagle.

(iv) Not every eagle is larger than any hawk.

[6]

(e) Give an example of an inference using *abduction*. Is this a *sound* method of inference? Justify your answer.

[4]

Question 4 **Natural Language**

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

s	$\longrightarrow$	np vp	det	$\longrightarrow$	[the]
np	$\longrightarrow$	np pp	n	$\longrightarrow$	[cat]
np	$\longrightarrow$	det n	n	$\longrightarrow$	[mouse]
pp	$\longrightarrow$	prep np	n	$\longrightarrow$	[hat]
vp	$\longrightarrow$	vp pp	n	$\longrightarrow$	[kitchen]
vp	$\longrightarrow$	v np	prep	$\longrightarrow$	[in]
			v	$\longrightarrow$	[sees]

(a) Write out three sentences which are generated by the above grammar, including at least one syntactically ambiguous sentence. Draw as many phrase-structure diagrams as you can for the ambiguous sentence.

[8]

(b) How can the above grammar be modified without increasing the number of phrase-structure rules (in the left-hand column) to generate sentences like *"The mice see the cats"* while still generating all sentences generated by the original grammar but *not* generating ungrammatical sentences like *"The mice sees the cats"*? Give examples of modified rules.

[8]

(c) (i) Explain the difference between *regular* and *context-free* grammars.

(ii) Is the above grammar a *regular grammar*? Justify your answer.

(iii) Give an example of a natural language construction which requires at least context-free power.

[9]

Question 5 **Philosophy of AI**

(a) Describe Alan Turing's "Imitation Game" (known to posterity as the *Turing Test*) and his responses to two possible objections to the idea of "thinking machines".

[10]

(b) Outline John Searle's distinction between "strong" and "weak" AI and summarise his arguments against strong AI. Do you think Alan Turing was defending "strong AI", "weak AI", or neither?

[10]

(c) Do you think the Turing Test is in fact an appropriate or important goal for AI research?

[5]