THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON **CO3310 ZA**

BSc Examination

COMPUTING AND INFORMATION SYSTEMS, CREATIVE COMPUTING and COMBINED DEGREE SCHEME

Artificial Intelligence

Monday 9 May 2016: 14.30 – 16.45

Duration: 2 hours 15 minutes

There are FIVE questions on this paper. Candidates should answer THREE questions. All questions carry equal marks, and full marks can be obtained for complete answers to THREE questions. The marks for each part of a question are indicated at the end of the part in [.] brackets.

Only your first THREE answers, in the order that they appear in your answer book, will be marked.

There are 75 marks available on this paper.

A handheld calculator may be used when answering questions on this paper but it must not be pre-programmed or able to display graphics, text or algebraic equations. The make and type of machine must be stated clearly on the front cover of the answer book.

QUESTION 1 Search and Planning

a) Explain in your own words the difference between uninformed and informed search. Describe one informed and one uninformed search strategy.

[4]

b) Explain in your own words the difference between progressive and regressive planning, and describe the major potential advantages and disadvantages of each approach.

[6]

c) The following figures show two states of an 8-puzzle.

1	2	3
8		4
7	6	5

Figure 1. Goal state

5	4	3
6		2
7	8	1

Figure 2. Start state

Describe two types of heuristic function for this kind of problem, and explain the minimum solution cost each would estimate for moving from the state in Figure 2 to that in Figure 1.

[6]

d) Assume a configuration of the blocks world as shown in Figure 3:

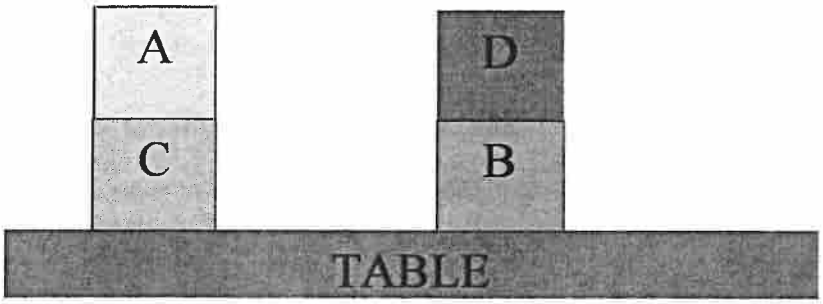

Figure 3. Start state

i. Define a set of actions in PDDL to move a single block on to another block (which may have blocks beneath it), or move a block onto the table.

ii. Using these actions, write down a solution to the problem of achieving the goal state in Figure 4, showing the effect of each move (note: the offset of the blocks is not significant).

[9]

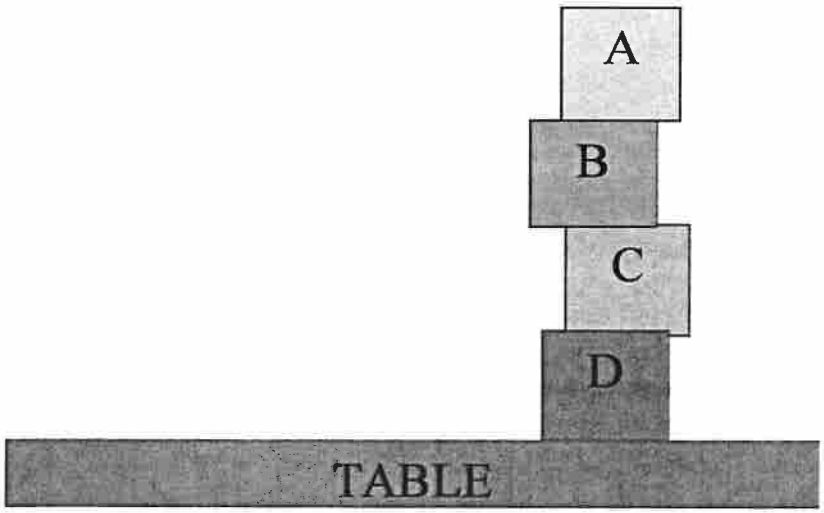

Figure 4. Goal state

QUESTION 2 Logic and Reasoning

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

[5]

b) Give the meaning of each the following formulas of Predicate Calculus in ordinary English:

i. $\forall x(\text{Swims}(x) \,\&\, \text{Bird}(x))$
ii. $\forall x((\text{Flies}(x) \,\&\, \text{Warm-Blooded}(x)) \rightarrow (\text{Bat}(x) \vee \text{Bird}(x)))$
iii. $\neg\exists x(\text{Cat}(x) \,\&\, \text{Fly}(x))$

[5]

c) Explain the following terms in the context of probabilistic reasoning:

i. Probability distribution
ii. Boolean random variable
iii. Continuous random variable
iv. Independent variables

[6]

d) Suppose there are 90,000 adult males in the city of Hiptown, of whom 30,000 are bearded and 5% have tattoos. If four out of five tattooed men have beards, what is the probability of a bearded male citizen having a tattoo? Calculate your answer to two decimal places, and explain it with reference to Bayes' Rule.

[9]

QUESTION 3 Natural Language

a) Describe three important differences between natural and formal languages, giving examples.

[6]

b) Explain the formal differences between regular, context-free and context-sensitive grammars. Give an example of a typical rule pattern for each type of grammar.

[6]

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

s → np vp	det → [the]
np → np pp	det → [a]
np →det n	n → [cat]
np → pn	n → [tree]
vp →vp pp	pn → [Alice]
vp → v np	v → [saw]
vp → v	v → [slept]
pp → p np	p → [in]

The start symbol is 's' which represents a sentence. Using the above grammar, draw as many syntax trees as you can for the sentences:

i. Alice saw a cat in the tree.
ii. The cat slept in the tree.

Explain how the grammar can be modified so that it still generates examples (i) and (ii) above and the new examples (iii) and (iv), but not the starred (v) and (vi):

iii. Alice saw a cat in a tree and a caterpillar on a mushroom
iv. Alice ate some cake and drank from a bottle
v. *Alice saw in the tree.
vi. *The cat slept a tree.

[9]

d) Explain how the formula *sees(Alice, Humpty)* can be derived from the English sentence *Alice sees Humpty*, using the lambda-calculus.

[4]

QUESTION 4 Machine Learning and Decisions

a) Describe two main types of **supervised learning** and propose a suitable application for each.

[4]

b) Explain the following terms in the context of machine learning:

a. reward
b. return
c. state-action value function
d. discount rate

[4]

c) Suppose you are developing a software tool to assist high school students in their choice of university, and you have access to various source of historical data. Discuss how **machine learning** techniques could be used to construct a **decision tree** to help in this choice.

[8]

d) Figure 5 represents a simple 4 x 3 world that presents a sequential decision problem. Draw a copy of this diagram and show an optimal policy for navigating it, given that:

- There are two terminal states with reward +100 and -100, and all other states have a reward of -1;
- The available actions are ←, ↑, → and ↓; each performs the intended action with a probability of 0.8, with probability of 0.1 of moving at 90 or 270 degrees respectively to the intended direction. Movement is one cell at a time and if an agent bumps against the outside boundary or a shaded cell, it stays where it is.
- There is no discounting.

Explain your answer. **[9]**

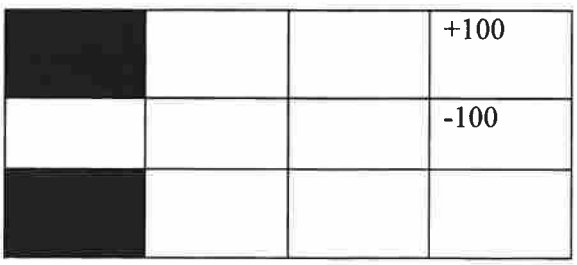

Figure 5.

QUESTION 5 Philosophy of AI and Social Issues

You should write no more than around 400-500 words for each of (a) and (b).

a)

Describe John Searle's "Chinese Room" thought experiment, which is claimed to demonstrate the impossibility of digital computers manifesting "strong AI". Suppose an alien being from a race of interplanetary robots were studying humanity, could it use a variant of Searle's argument to prove that humans are not really intelligent or conscious beings? Justify your answer.

[10]

b) The renowned physicist Stephen Hawking, a member of Cambridge University's Centre for the Study of Existential Risk, argues that the continuing development of "artificial general intelligence" or AGI may threaten the future existence of humanity:

"One can imagine such technology outsmarting financial markets, out-inventing human researchers, out-manipulating human leaders, and developing weapons we cannot even understand. Whereas the short-term impact of AI depends on who controls it, the long-term impact depends on whether it can be controlled at all."

(Independent, May 2014)

Do you consider Professor Hawking's fears to be reasonable and justified, and if so, what steps should be taken to minimise any risks posed by this technology? Justify your answer. **[15]**

END OF PAPER