

UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

Department of Computing

B. Sc. Examination 2018

IS53024A

Artificial Intelligence

Duration: 2 hours 15 minutes

Date and time:

This paper is in two parts: part A and part B. You should answer ALL questions from part A and TWO questions from part B. Part A carries 40 marks, and each question from part B carries 30 marks. The marks for each part of a question are indicated at the end of the part in [.] brackets.

There are 100 marks available on this paper.

No calculators should be used.

**THIS PAPER MUST NOT BE REMOVED
FROM THE EXAMINATION ROOM**

Part A

Question 1

- (a) Define *rational agent*. [5]
- (b) Suppose that a room thermostat turns the heating on if the room is too cold, and otherwise turns the heating off. Argue that the thermostat is a rational agent. [5]
- (c) Suggest an appropriate performance measure for the thermostat in part (b) above. [5]
- (d) Write an agent function for the thermostat in part (b) above. [5]

Question 2

- (a) Consider the following facts and rules for rule-based system inference:

```
(FACT 1 ( E ))  
(FACT 2 ( F ))  
(FACT 3 ( C ))  
(FACT 4 ( H ))  
(RULE 1 (IF (( A ) and ( C ) and ( E )) (THEN ( D ))))  
(RULE 2 (IF (( H )) (THEN ( A ))))  
(RULE 3 (IF (( D ) and ( F )) (THEN ( B ))))
```

Prove that the goal (B) is true and give the sequences of backward rule firings using the rules and facts in the order in which they are given. [15]

- (b) Explain briefly what is the relationship between the sequences of firing the rules during forward chaining and backward chaining in for rule-based system inference. [5]

Part B

Question 3

- (a) Write, in pseudocode, a *Simple Tree Search* algorithm. Your answer should not specify how a node is chosen for expansion. [5]
- (b) Modify your answer to (a) so that the pseudocode implements *depth-first search*. [5]
- (c) Explain, with reference to four performance measures, the advantages and disadvantages of depth-first search. [5]
- (d) Modify the depth-first algorithm in part (b) so that it implements *depth-limited search*. [5]
- (e) Compare depth-limited search to depth-first search. [5]
- (f) *Iterative deepening search* launches a series of depth-limited searches of increasing limit and terminates when the goal is found. Explain how iterative-deepening avoids the disadvantages of depth-limited search. [5]

Question 4

- (a) Explain briefly the forward chaining algorithm for rule-based production systems. [6]
- (b) Explain briefly the backward chaining algorithm for rule-based production systems. [6]
- (c) Demonstrate the operation of the forward chaining algorithm for rule-based systems using the following first-order rules and facts:

```
(RULE 1 (IF (Dog ?x)
            (THEN (Animal ?x))))
```

```
(RULE 2 (IF (AnimalLover ?x) (Animal ?y))
            (THEN (Feeds ?x ?y)))
```

```
(RULE 3 (IF (Dog ?x) (Owns ?y ?x))
            (THEN (AnimalLover ?y)))
```

```
(FACT 1 (Dog Dany)
```

```
(FACT 2 (Owns Jack Dany)
```

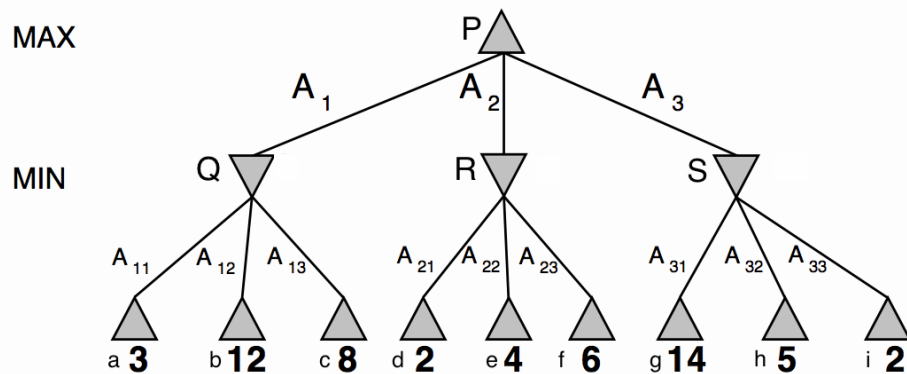
Give the variable bindings at each step of the forward chaining algorithm. Use the rules and facts in the given order. [18]

Question 5

- (a) Imagine a roomful of identical rational agents playing the following game: each agent has to secretly pick a real number between 0 and 100 inclusive. The winner is the agent who is closest to $2/3$ of the average of all the numbers.

What is the pure strategy Nash equilibrium? Explain your answer. [5]

- (b) The diagram below shows a game tree for a 2 ply game. Use the *minimax* algorithm to calculate the utilities at nodes P, Q, R and S. [5]



- (c) Assume the terminal nodes are evaluated from left to right, i.e. a , then b , then c etc. Can any of the terminal nodes be pruned? Explain your answer. [5]

- (d) Let a concept description language with 3 attributes be given for symbolic machine learning. Assume that these attributes take the following values:

a1	a2	a3
b	c	a
g	d	f
e		

Interpret the behaviour of the candidate elimination algorithm using the following positive and negative training examples:

1. (b d a) +)
2. (g e f) -)
3. (b c a) +)

- Illustrate the changes of the boundary sets after the first example. [5]
- Illustrate the changes of the boundary sets after the second example. [5]
- Illustrate the changes of the boundary sets after the third example. [5]