King's College London

This paper is part of an examination of the College counting towards the award of a degree. Examinations are governed by the College Regulations under the authority of the Academic Board.

Degree Programmes	MSc, MSci
Module Code	7CCSMAMS
Module Title	Agents and Multi-Agent Systems
Examination Period	January 2018 (Period 1)
Time Allowed	Two hours
Rubric	ANSWER THREE OF FOUR QUESTIONS. ANSWER EACH QUESTION ON A NEW PAGE OF YOUR ANSWER BOOK AND WRITE ITS NUMBER IN THE SPACE PROVIDED. All questions carry equal marks. If more than three questions are answered, the three answers with highest marks will count.
Calculators	Calculators may be used. The following models are permitted: Casio fx83 / Casio fx85.
Notes	Books, notes or other written material may not be brought into this examination

PLEASE DO NOT REMOVE THIS PAPER FROM THE EXAMINATION ROOM

1. a. Consider a situation in which two agents 1 and 2 bid for items a and b. We assume each agent is only able to obtain at most one item. In other words, $\langle Z_1, Z_2 \rangle$ is a possible allocation of the goods if and only if the following conditions all hold:

1. $(Z_1 \cup Z_2) \subseteq \{a, b\}$,
2. $Z_1 \cap Z_2 = \emptyset$, and
3. for all $i \in \{1, 2\}$: $Z_i \in \{\{\}, \{a\}, \{b\}\}$.

The agents have the following valuation functions.

$$v_1(\{a\}) = 6 \qquad v_1(\{b\}) = 3 \qquad v_2(\{a\}) = 9 \qquad v_2(\{b\}) = 1$$

The outcome is determined by the Vickrey-Clarke-Groves mechanism (VCG mechanism).

i. Specify all the possible allocations and give the social welfare of each.

[3 marks]

ii. Which allocation will be assigned if both agents are truthful about their valuations?

[2 marks]

iii. How much will each agent have to pay to the mechanism for the allocation you determined as the answer to Question 1.a.ii? Show your workings.

[6 marks]

iv. What utility will each agent get if they are truthful about their valuations?

[2 marks]

v. The dominant strategy for each agent is to provide their true valuation. Show this to be the case by explaining why agent 1 does not have any incentive to lie about its valuation.

[6 marks]

QUESTION 1 CONTINUES ON NEXT PAGE

b. Auctions on eBay are ascending price open-cry auctions but with a proxy bidding system, which proceeds as follows.

- The auctioneer sets a reserve price and an ending time.
- Potential buyers use a proxy bidding system. They submit a maximum value to the proxy bidding system (this must be higher than the reserve price and the current auction price) which then makes incremental ascending bids on their behalf until their maximum value is reached.
- The potential buyers are able to increase their maximum value at any point during the auction, as long as it is higher than the current auction price.
- The proxy bidding system ensures that the bidder who submits the maximum value wins the auction and the price they pay is the maximum value of the second highest bidder (plus a small increment).

Consider the following three possible bidder strategies.

- *Maxing*: At the start of the auction, submit a maximum value to the proxy bidding system that is equal to your true valuation of the item and then wait for the auction to close.
- *Increments*: If you are not the highest bidder, submit a maximum value to the proxy bidding system that is the current auction price plus the smallest increment possible until you reach your true valuation of the item.
- *Sniping*: Wait until just before the auction ends, i.e., at the last possible point when a bid can be submitted, and then submit a maximum value to the proxy bidding system that is equal to your true valuation of the item.

QUESTION 1 CONTINUES ON NEXT PAGE

Assume there are only two potential buyers for an eBay auction, BuyerA and BuyerB. BuyerA's true valuation of the item is £50 and BuyerB's true valuation of the item is £60. The reserve price is £40 and the increment value is £1. What would be the outcome of the auction in the following situations? Say who would win the auction and what price they would end up paying.

i. BuyerA uses maxing and BuyerB uses maxing.

[2 marks]

ii. BuyerA uses increments and BuyerB uses sniping.

[2 marks]

iii. BuyerA uses increments and BuyerB uses maxing.

[2 marks]

c. i. What is the *winner's curse*?

[2 marks]

ii. Consider an eBay auction as described in Question 1.b where all the bidders are using the maxing strategy. Does the winner of the auction risk suffering from the *winner's curse*? Justify your answer.

[6 marks]

2. a. Consider the following scenario:

> Your personal digital assistant (PDA) sees that you have received an email inviting you to give a talk at a conference in Buenos Aires next year. Your PDA knows that giving this talk will be good for your career and that you have always wanted to visit South America, so it immediately starts to arrange some provisional travel and accommodation plans. It communicates with several travel operator digital agents to identify the best deal and sends you a message that gives details of this deal and explains why it is your best option.

i. Explain whether you think it would be appropriate to model the PDA from the scenario above as an agent. Make sure you refer to each of the main properties of intelligent agents and explain how they relate to the scenario.

[8 marks]

ii. When interacting with you, your PDA does so through *argumentation-based dialogues*. Explain why it is appropriate for your PDA to communicate with you through an argumentation-based dialogue in this scenario.

[6 marks]

QUESTION 2 CONTINUES ON NEXT PAGE

b. The pseudo-code below defines the control loop for a practical reasoning agent.

```
1.  B := B0;       /* B0 is initial value of B */
2.  I := I0;       /* I0 is initial value of I */
3.  while true do
4.       get next percept ρ;
5.       B:= brf(B, ρ);
6.       D:= options(B, I);
7.       I:= filter(B, D, I);
8.       π:= plan(B, I);
9.       while not empty(π) do
10.           α:= hd(π);
11.           execute(α);
12.           π:= tail(π);
13.           get next percept ρ;
14.           B:= brf(B, ρ);
15.           if not sound(π, I, B) then
16.               π:= plan(B, I);
17.           end-if
18.       end-while
19.  end-while
```

i. Identify any situations in which you think this agent would not behave optimally, making reference to the pseudo-code to explain your answer.

[6 marks]

ii. Explain clearly how you would modify the pseudo-code in order to improve the agent's performance.

[6 marks]

QUESTION 2 CONTINUES ON NEXT PAGE

c. If an agent has the property of "calculative rationality when deliberating" this means that the intentions the agent selects will be those that were optimal when it started the process of deliberation.

Assume an agent with the property of calculative rationality is acting in a dynamic environment. What consequences might the agent observe as a result of having the property of calculative rationality and what steps might it need to take as a result of this?

[7 marks]

3. Two robots (R_1 and R_2) are collecting valuable items (v_1, v_2 and v_3) from an abandoned warehouse. All valuable items must be collected and each valuable item is collected by a single robot.

We can define this scenario as a task-oriented domain (TOD) as follows

$$\langle \{v_1, v_2, v_3\}, \{R_1, R_2\}, c \rangle$$

where the cost function c is defined as

$$\begin{array}{ll} c(\emptyset) = 0 & c(\{v_1\}) = 3 \\ c(\{v_2\}) = 8 & c(\{v_3\}) = 4 \\ c(\{v_1, v_2\}) = 11 & c(\{v_1, v_3\}) = 7 \\ c(\{v_2, v_3\}) = 12 & c(\{v_1, v_2, v_3\}) = 15 \end{array}$$

The initial encounter in the above scenario is $\delta = \langle \{v_1, v_2\}, \{v_3\} \rangle$ and the agents are following the monotonic concession protocol.

a. Briefly describe the monotonic concession protocol for negotiation.

[7 marks]

b. What is the utility of the deal $\delta' = \langle \{v_1\}, \{v_2, v_3\} \rangle$ for robot R_1?

[1 marks]

c. What is the utility of the deal $\delta' = \langle \{v_1\}, \{v_2, v_3\} \rangle$ for robot R_2?

[1 marks]

d. Which of the possible deals are Pareto optimal?

[4 marks]

e. Which of the possible deals are individual rational?

[4 marks]

QUESTION 3 CONTINUES ON NEXT PAGE

f. Which of the possible deals are in the negotiation set? Explain your answer.

[4 marks]

g. If the robots negotiate the task allocation in the scenario above, what will the outcome be? Explain your answer.

[4 marks]

h. Can either agent benefit from deceiving the other by hiding one of its tasks? Explain your answer.

[8 marks]

4. a. Consider the following voter profile:

40 voters:	$B \succ C \succ A \succ D$
30 voters:	$C \succ B \succ A \succ D$
25 voters:	$D \succ B \succ C \succ A$
5 voters:	$A \succ C \succ B \succ D$

Identify who is the winner under each of the following voting rules. Show your workings.

- *Plurality*.
- *Instant runoff*.
- *Borda count*.
- *Copeland rule*.

[10 marks]

QUESTION 4 CONTINUES ON NEXT PAGE

b. Consider the following voter profile:

43 voters:	$A \succ B \succ C$
12 voters:	$B \succ A \succ C$
45 voters:	$C \succ B \succ A$

The winner is determined through a linear sequence of pairwise elections with the following agenda:

$$A, B, C$$

i. What is the outcome? Show your workings.

[4 marks]

ii. Construct the majority graph for this voter profile.

[3 marks]

iii. Is it possible to fix the agenda to give a different winner than you determined for Question 4.b.i? Explain the reasons for your answer.

[6 marks]

c. Suppose that (s_1, s_2, s_3) is an arbitrary *Positional Scoring Rule (PSR)*, where s_1, s_2, s_3 are positive whole numbers such that $s_1 \geq s_2 \geq s_3$ and $s_1 > s_3$. Show that this voting rule does not select the Condorcet winner.

[10 marks]