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 2016 (Period 1)
Time Allowed	Two hours
Rubric	ANSWER THREE OF FIVE QUESTIONS.
	Each question is worth in total 50 marks. Write your answers in the answer booklets provided. If more than three questions are answered, the three questions with the 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 the following payoff matrix.

		i: defect	i: cooperate
j	**defect**	-1 -1	2 1
	cooperate	1 2	-1 -1

i. Explain the notion of a dominant strategy. For each of the agents (for agent i and for agent j) identify any dominant strategies in the game defined in the payoff matrix above. Justify your answer.

[9 marks]

ii. Explain the notion of a Nash equilibrium and identify any Nash equilibria that exist in the game defined in the payoff matrix above.

[9 marks]

iii. Explain the notion of a Pareto optimal outcome and identify all outcomes of the game defined in the payoff matrix above that are **not** Pareto optimal, explaining why this is the case.

[9 marks]

iv. Is the game defined in the payoff matrix above strictly competitive? Justify your answer.

[9 marks]

QUESTION 1 CONTINUES ON NEXT PAGE

b. The payoff matrix for the prisoner's dilemma is given below.

		i: defect	i: cooperate
j	**defect**	2 2	1 4
	cooperate	4 1	3 3

i. Explain why the TIT-FOR-TAT strategy (which cooperates on the first round and on each round $t > 1$ does what its opponent did on round $t - 1$) won Axelrod's iterated prisoner's dilemma tournament. Make sure your explanation identifies the dominant strategy for the prisoner's dilemma and describes the performance of TIT-FOR-TAT when playing against the dominant strategy.

[8 marks]

ii. An agent in a multi-agent system encounters another agent for the first time and they enter into an interaction that has the same payoff matrix as the prisoner's dilemma. Do you think it is rational for the agent to use the TIT-FOR-TAT strategy in this encounter? Make sure you explain your answer and identify any assumptions you make.

[6 marks]

2. 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

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

a. What is a deal for the above scenario?

[4 marks]

b. List all the possible deals for the above scenario.

[4 marks]

QUESTION 2 CONTINUES ON NEXT PAGE

c. Assume the initial encounter in the above scenario is $\delta = \langle\{v_1, v_2\}, \{v_3\}\rangle$.

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

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

iii. Which of the possible deals are Pareto optimal?
[8 marks]

iv. Which of the possible deals are individual rational?
[8 marks]

v. Which of the possible deals are in the negotiation set? Explain your answer.
[8 marks]

vi. If the robots negotiate the task allocation in the scenario above, what will the outcome be? Explain your answer.
[10 marks]

3. a. What does it mean if an item for sale at an auction has *correlated value*? Give an example of an item with correlated value.

[4 marks]

b. What does it mean if an item for sale at an auction has *private value*? Give an example of an item with private value.

[4 marks]

c. Outline the protocol for the following types of auction:

i. English

ii. Dutch

iii. First price sealed bid

iv. Vickrey

[12 marks]

d. What is the *dominant strategy* when participating in a Vickrey auction? Explain why the strategy you have described is dominant.

[10 marks]

QUESTION 3 CONTINUES ON NEXT PAGE

e. Consider an auction over a single item with private value. There are four bidding agents (Ag_1, Ag_2, Ag_3 and Ag_4). Ag_1 values the item at 10, Ag_2 values the item at 30, Ag_3 values the item at 20 and Ag_4 values the item at 15.

Assume the agents are all behaving rationally (that is, they are seeking to maximise their utility). If an agent wins the auction, its utility is equal to their valuation of the item minus the price they pay for it; if an agent does not win the auction, its utility is zero.

Further assume that agent Ag_2 knows how much each of the other agents values the item by, but that the other agents only know their own evaluation.

Explain what agent Ag_2 should do in each of the following auctions and what the outcome would be (that is, say who would win the auction and how much they would pay for the item).

i. English

ii. Dutch

iii. First price sealed bid

iv. Vickrey

[20 marks]

4. a. Explain, with the aid of examples, the three different aspects of a speech act.

[9 marks]

b. Describe, with the aid of examples, the following types of speech act:

i. representatives

ii. directives

iii. commissives

iv. expressives

v. declarations

[15 marks]

QUESTION 4 CONTINUES ON NEXT PAGE

c. Consider an argumentation based dialogue system with two participating agents and whose topic is an argument about a belief. Each agent has a knowledge base (its beliefs), which is a finite set of arguments about beliefs, and uses the grounded semantics to reason about the acceptability of arguments. The dialogue system is defined as follows.

Moves:

- An agent can `ASSERT` an argument.
- An agent can make a `CLOSE` move.

Protocol:

- The agents take it in turn to make a move.
- The first agent to move `ASSERT`s an argument, which causes that argument to become the `TOPIC` of the dialogue.
- For all other turns:
  - An agent can `ASSERT` an argument as long as it has not previously been asserted and it attacks some argument that has previously been asserted during the dialogue.
  - An agent can always make a `CLOSE` move.

Termination rules:

- A dialogue terminates if each agent makes a `CLOSE` move in succession (i.e. one agent makes a `CLOSE` move and then the other agent makes a `CLOSE` move immediately afterwards).
- If the `TOPIC` of the dialogue is acceptable given the abstract argumentation framework that is constructed from all of the arguments that have been asserted during the dialogue, then the outcome of the dialogue is `Acceptable(TOPIC)`.
- If the `TOPIC` of the dialogue is not acceptable given the abstract argumentation framework that is constructed from all of the arguments that have been asserted during the dialogue, then the outcome of the dialogue is `NotAcceptable(TOPIC)`.

QUESTION 4 CONTINUES ON NEXT PAGE

i. Assume both of the agents are using Strategy 1 given below. Which type of dialogue (from Walton and Krabbe's dialogue typology) would this produce? Explain your answer.

> Strategy 1: If it is permissible to `ASSERT` an argument from your beliefs, then `ASSERT` some such an argument; otherwise make a `CLOSE` move.

[8 marks]

ii. Assume both of the agents are using Strategy 2 given below. Which type of dialogue (from Walton and Krabbe's dialogue typology) would this produce? Explain your answer.

> Strategy 2: If it is permissible to `ASSERT` an argument from your beliefs and adding that argument to the abstract argumentation framework that is constructed from all of the arguments that have been asserted so far during the dialogue causes the label (i.e. `IN`, `OUT`, or `UNDECIDED`) of the `TOPIC` to change, then `ASSERT` such an argument; otherwise make a `CLOSE` move.

[8 marks]

QUESTION 4 CONTINUES ON NEXT PAGE

iii. Assume the agent who starts the dialogue is using Strategy 3 and the other agent is using Strategy 4, as given below. Which type of dialogue (from Walton and Krabbe's dialogue typology) would this produce and why?

Strategy 3: If it is permissible to `ASSERT` an argument from your beliefs and adding that argument to the abstract argumentation framework that is constructed from all of the arguments that have been asserted so far during the dialogue causes the label of the `TOPIC` to change to `IN`, then `ASSERT` such an argument; otherwise make a `CLOSE` move.

Strategy 4: If it is permissible to `ASSERT` an argument from your beliefs and adding that argument to the abstract argumentation framework that is constructed from all of the arguments that have been asserted so far during the dialogue causes the label of the `TOPIC` to change to `OUT`, then `ASSERT` such an argument; otherwise make a `CLOSE` move.

[10 marks]

5. a. Briefly explain how the winner is decided under each of the following voting rules:

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

[16 marks]

b. Consider the following voter profile:

20 voters:	$B \succ C \succ A \succ D$
30 voters:	$C \succ B \succ A \succ D$
40 voters:	$D \succ A \succ B \succ C$
10 voters:	$A \succ D \succ B \succ C$

Identify who is the winner under each of the following voting rules:

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

[16 marks]

QUESTION 5 CONTINUES ON NEXT PAGE

c. Consider the following voter profile:

4 voters:	$A \succ B \succ C$
3 voters:	$B \succ C \succ A$
2 voters:	$B \succ A \succ C$
2 voters:	$C \succ A \succ B$

Identify the *Condorcet winner*. Show your workings.

[4 marks]

d. 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.

[14 marks]