This document is intended to be exported as Anki flashcards.
Answers generated/derived by/from AI are coloured in blue! (Gemini/NotebookLM in use)
"Open-book" answers are marked as purple, corrections from model solutions are coloured as green.
Any arguments arising from group discussion are marked as fuchsia.

7CCSMAMS
Practice Questions

If you spot anything wrong, please let me know!
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Contents

1. Tutorial 1

Q1

The Mars Rover is designed to explore Mars, consider why it needs some autonomy, what the rover needs to reason about to be able to autonomously travel to, collect, and analyse a sample, and how the environment might disrupt its plans.

The Mars Rover is so far from Earth that it cannot be controlled in real-time remotely, it must be able to make decisions and operate in isolation.

The environment is constantly changing and the rover could be subject to adverse weather conditions such as storms. It may mean certain components need to be shielded, protected, or otherwise cannot be used. Such as to protect from loose debris hitting the rover or from extreme temperatures which could negatively impact the system.

The rover needs to be able to reason about whether it is possible to reach and collect a sample, this includes factors such as:
- *understand sensor data such as acceleration, temperature, position, point data, etc*
- *ability to travel to the sample given the amount of energy it can expend in a given day*
- *ability to travel to a sample given weather conditions; it may not be possible to move without potential damage*
- *ability to collect a sample given weather conditions; for example, in cold temperatures it may be possible the soil cannot be collected*
- *ability to analyse a sample; a critical component may be unavailable or broken so the rover must be able to sense and reason about operations it can perform*

Q2

There is a convoy of autonomous vehicles travelling along the motorway, what are the goals of an autonomous vehicle in a convoy, what might it have to react to at short notice, and how might we express rules for following the convoy while retaining its ability to react to situations?

The vehicle's primary goal is to either lead or follow a leading vehicle matching their speed (within safe limits) or setting an appropriate speed based on traffic conditions.

It must react to sudden changes in traffic and weather conditions. Vehicles may break down or unexpectedly stop. The road may momentarily become slippery if it starts raining and the vehicles must slow down accordingly.

We could specify hard limits for the vehicle such as:
- *Maximal speed based on location and road conditions*
- *Maximal speed based on traffic*
- *Maximal acceleration*
- *Minimum distance to vehicle in front (stopping distance)*

In some cases, the ordering may need to stay consistent or it could be flexible and change. Presidential motorcade must stay in a particular order while delivery trucks may reorder.

We can use different models of computing to design this:
- *Centralisation: all vehicles adhere to a central system*
- *Decentralisation: all vehicles operate independently with some goal*
- *Distributed computing: vehicles operate as one with each vehicle providing sensor data and edge computing*

Q3

“A lift is capable of moving from floor to floor. Its sole desire is to help humans to get to where they want to be. We tell the lift that we want it to go by pressing the appropriate floor button in the lift. The lift will travel to a floor it believes there is someone waiting at who wants its help, or if it believes that it is carrying a passenger who wants to get to that floor.”

Ascribing intentional notions to a machine is **legitimate** when such an ascription expresses the same information about the machine that it expresses about a person. It is **useful** when the ascription helps us understand the structure of the machine, its past or future behaviour, or how to repair or improve it.

Is it (a) useful and (b) legitimate to describe the behaviour of the lift in this way?

Intentional notions are a good abstraction when we can’t easily describe the mechanical workings, such as the how the brain would work.

It’s a practical way to simply explain how a system works. However mechanical explanations such as those for a list are often more useful in implementation.

It may be argued it is not legitimate as it provides a fictional truth, i.e. it isn’t the reality.

2. Topic 7

Plurality voting protocol - question

$\Omega = \{\omega_1, \omega_2, \omega_3\}$

1. 50 agents have the preference $\omega_1 \succ \omega_2 \succ \omega_3$
2. 10 agents have the preference $\omega_2 \succ \omega_3 \omega_1$
3. 20 agents have the preference $\omega_3 \succ \omega_2 \succ \omega_1$
4. 20 agents have the preference $\omega_3 \succ \omega_1 \succ \omega_2$

Which candidate is the winner under the plurality voting protocol?

- ✓ ω_1 = 50
- ✗ ω_2 = 10
- ✗ ω_3 = 40

Condorcet winner - question

Suppose we have 5 voters and:

$\Omega = \{\omega_1, \omega_2, \omega_3\}$
$\omega_1 \underset{1}{\succ} \omega_2 \underset{1}{\succ} \omega_3$
$\omega_1 \underset{2}{\succ} \omega_2 \underset{2}{\succ} \omega_3$
$\omega_3 \underset{3}{\succ} \omega_2 \underset{3}{\succ} \omega_1$
$\omega_2 \underset{4}{\succ} \omega_1 \underset{4}{\succ} \omega_3$
$\omega_2 \underset{5}{\succ} \omega_3 \underset{5}{\succ} \omega_1$

Which candidate is the Condorcet winner?

- ✗ ω_1
- ✓ ω_2
- ✗ ω_3
- ✗ There is no Condorcet winner for this example.

ω_1 to ω_2 = 2:3 therefore $\omega_2 \succ \omega_1$
ω_2 to ω_3 = 4:1 therefore $\omega_2 \succ \omega_3$
ω_1 to ω_3 = 3:2 therefore $\omega_1 \succ \omega_3$

Linear sequential majority elections - question

Let $\Omega = \{A, B, C\}$. Consider profile:
- 3 voters have preference $A \succ B \succ C$
- 2 voters have preference $B \succ C \succ A$
- 1 voter has preference $B \succ A \succ C$
- 1 voter has preference $C \succ A \succ B$

Vote is carried out with agenda A, C, B, who is the winner?

- ✓ A
- ✗ B
- ✗ C

A vs. C: 3+1:2+1 = 4:3 therefore A wins
A vs. B: 3+1:2+1 = 4:3 therefore A wins

Consider the following majority graph:

$$\begin{tikzcd}
A \arrow[r] \arrow[d] & B \arrow[d] \\
C \arrow[ur] & D \arrow[l] \arrow[ul]
\end{tikzcd}$$

Which of the following statements are true?

- ✓ It is possible to fix the agenda so that B wins under linear sequential election voting.
- ✓ It is possible to fix the agenda so that C wins under linear sequential election voting.
- ✓ It is possible to fix the agenda so that A wins under linear sequential election voting.
- ✓ It is possible to fix the agenda so that D wins under linear sequential election voting.

Instant runoff question

Consider voting profile:

- 20 voters: $B \succ C \succ A \succ D$
- 50 voters: $C \succ B \succ A \succ D$
- 15 voters: $D \succ A \succ C \succ B$
- 5 voters: $A \succ C \succ B \succ D$

Who is the winner under instant runoff voting?

- ✗ A
- ✗ B
- ✓ C
- ✗ D

Eliminations in order:

- A eliminated with 5 votes
- D elimianted with 15 votes
- B eliminated with 20 votes; C has 70 votes at this stage

Copeland rule question

Consider voting profile:

- 20 voters: $B \succ C \succ A \succ D$
- 50 voters: $C \succ B \succ A \succ D$
- 15 voters: $D \succ B \succ C \succ A$
- 5 voters: $A \succ C \succ B \succ D$

Who is the winner under the Copeland rule voting protocol?

- ✗ A
- ✗ B
- ✓ C
- ✗ D

Calculations performed:

- A:B is 5:85; A:C is 5:85, A:D is 75:15; B:C is 35:55; B:D is 75:15; C:D is 75:15
- $B \succ A$, $C \succ A$, $A \succ D$, $C \succ B$, $B \succ D$, $C \succ D$
- A = −1-1+1 (-1)
- B = 1-1+1 (1)
- C = 1+1+1 (**3**)
- D = −1-1-1 (-3)

Borda count question

Consider voting profile:

- 20 voters: $B \succ C \succ A \succ D$
- 50 voters: $C \succ B \succ A \succ D$
- 15 voters: $D \succ B \succ C \succ A$
- 5 voters: $A \succ C \succ B \succ D$

Who is the winner under the Borda count protocol?

- ✕ A
- ✕ B
- ✓ C
- ✕ D

Calculations performed:

- A = 20(1) + 50(1) + 15(0) + 5(3) = 85
- B = 20(3) + 50(2) + 15(2) + 5(1) = 195
- C = 20(2) + 50(3) + 15(1) + 5(2) = **215**
- D = 20(0) + 50(0) + 15(3) + 5(0) = 45

3. Topic 8

Consider an English auction with two bidders, ag1 and ag2, who are each playing their dominant strategy.

We have $v_1 = 7.5, v_2 = 300$ where v_i is ag$_\text{i}$'s true valuation of the item.

The minimum bid increment allowed is 1, and the auctioneer starts the bidding at 5.

How much will the auctioneer receive? (In other words, how much will the winning bidder end up paying for the item?) Assume that ag1 is always faster to bid than ag2 (that is, if both agents are willing to make a bid of b, ag1 will always be the agent who bids b).

- Agent 1 bids 5
- Agent 2 bids 6
- Agent 1 bids 7
- Agent 2 bids 8 (**final bid is 8**)

Consider an English auction with two bidders, ag1 and ag2, who are each playing their dominant strategy.

We have $v_1 = 10, v_2 = 8.5$ where v_i is ag$_\text{i}$'s true valuation of the item.

The minimum bid increment allowed is 0.5, and the auctioneer starts the bidding at 8.5.

The auctioneer has colluded with another dishonest bidder to place shill bids. **In which of the following scenarios can the auctioneer expect to increase their profit through the placing of these shill bids?** Assume that ag2 is always the fastest to bid (that is: if ag2 and one of the other agents is willing to make a bid of b, then ag2 will always be the agent who bids b).

- ✗ The shill bidder will make the smallest possible bid as long as the current bid amount is ≤ 15.
- ✗ The shill bidder will make the smallest possible bid as long as the current bid amount is ≤ 8.5.
- ✓ The shill bidder will make the smallest possible bid as long as the current bid amount is ≤ 9.5.

Which of the following two statements is true?

- ✗ If the bidders are all extremely risk seeking, the auctioneer can expect to make more from a Dutch auction than an English auction.
- ✓ If the bidders are all extremely risk seeking, the auctioneer can expect to make more from an English auction than a Dutch auction.

In a Vickrey auction: bidders submit a private bid to the auctioneer; there are no subsequent rounds; the agent with the highest bid wins and they pay the price of the second highest bid.

Which of the following statements do you think is true?

- ✗ The dominant strategy for a bidder in a Vickrey auction is to bid more than your true valuation.
- ✓ The dominant strategy for a bidder in a Vickrey auction is to bid the same as your true valuation.
- ✗ The dominant strategy for a bidder in a Vickrey auction is to bid less than your true valuation.

Suppose we have the following situation:

$\mathcal{Z} = \{z_1, z_2, z_3\}$ (i.e., the items up for auction are z_1, z_2 and z_3)

$Ag = \{ag_1, ag_2\}$ (i.e., there are two bidders: ag_1 and ag_2)

$v_1(\emptyset) = 0$ (i.e., $\emptyset$ is worth 0 to ag_1)

$v_1(\{z_1\}) = 1$ (i.e., $\{z_1\}$ is worth 1 to ag_1)

$v_1(\{z_2\}) = 3$ (i.e., $\{z_2\}$ is worth 3 to ag_1)

$v_1(\{z_3\}) = 2$ (i.e., $\{z_3\}$ is worth 2 to ag_1)

$v_1(\{z_1, z_2\}) = 3$ (i.e., $\{z_1, z_2\}$ is worth 3 to ag_1)

$v_1(\{z_1, z_3\}) = 5$ (i.e., $\{z_1, z_3\}$ is worth 5 to ag_1)

$v_1(\{z_2, z_3\}) = 6$ (i.e., $\{z_2, z_3\}$ is worth 6 to ag_1)

$v_1(\{z_1, z_2, z_3\}) = 6$ (i.e., $\{z_1, z_2, z_3\}$ is worth 6 to ag_1)

$v_2(\emptyset) = 0$ (i.e., $\emptyset$ is worth 0 to ag_2)

$v_2(\{z_1\}) = 5$ (i.e., $\{z_1\}$ is worth 5 to ag_2)

$v_2(\{z_2\}) = 1$ (i.e., $\{z_2\}$ is worth 1 to ag_2)

$v_2(\{z_3\}) = 1$ (i.e., $\{z_3\}$ is worth 1 to ag_2)

$v_2(\{z_1, z_2\}) = 5$ (i.e., $\{z_1, z_2\}$ is worth 5 to ag_2)

$v_2(\{z_1, z_3\}) = 5$ (i.e., $\{z_1, z_3\}$ is worth 5 to ag_2)

$v_2(\{z_2, z_3\}) = 1$ (i.e., $\{z_2, z_3\}$ is worth 1 to ag_2)

$v_2(\{z_1, z_2, z_3\}) = 5$ (i.e., $\{z_1, z_2, z_3\}$ is worth 5 to ag_2)

Which of the following allocations produces the highest social welfare?

- ✗ $\langle \emptyset, \{z_1, z_2, z_3\} \rangle$
- ✗ $\langle \{z_1, z_2, z_3\}, \emptyset \rangle$
- ✗ $\langle \{z_2\}, \{z_1\} \rangle$
- ✓ $\langle \{z_2, z_3\}, \{z_1\} \rangle$

Suppose we have two items a and b and two agents ag_1 and ag_2 who can obtain at most one item.

Agents declare valuation functions:
$v_1(\{a\}) = 7$
$v_1(\{b\}) = 2$
$v_2(\{a\}) = 5$
$v_2(\{b\}) = 4$

What allocation will be made under the VCG mechanism? $\langle\{a\}, \{b\}\rangle$

Suppose we have two items a and b and two agents ag_1 and ag_2 who can obtain at most one item.

Agents declare valuation functions:
$v_1(\{a\}) = 7$
$v_1(\{b\}) = 2$
$v_2(\{a\}) = 5$
$v_2(\{b\}) = 4$

The allocation is $\langle\{a\}, \{b\}\rangle$.

How much will agent ag_1 and ag_2 have to pay to the auctioneer?
- Assume agent 1's valuation is zero, new allocation is: $\langle\{b\}, \{a\}\rangle$
- Therefore $p = 5 - 4 = 1$
  $p = \text{social welfare with agent 1's valuation as zero} - \text{social welfare without agent 1}$

Agent 2's $p = 0$.

Suppose we have two items a and b and two agents ag_1 and ag_2 who can obtain at most one item.

Agents declare valuation functions:
$v_1(\{a\}) = 7$
$v_1(\{b\}) = 2$
$v_2(\{a\}) = 5$
$v_2(\{b\}) = 4$

The allocation is $\langle\{a\}, \{b\}\rangle$.
ag_1 pays 1 to auctioneer.
ag_2 pays 0 to auctioneer.

What utilities will they end up with?
- Agent 1: $7 - 1 = 6$
- Agent 2: $4 - 0 = 4$

4. Topic 9

Consider the database $\Delta = \{a, b, d, e, f, a \wedge b \to c, d \to \neg b, \neg b \wedge e \to f, g \to \neg c\}$.

Which of the following arguments can we construct?

- ✓ $\langle\{d, d \to \neg b\}, \neg b\rangle$
- ✓ $\langle\{a, b, a \wedge b \to c\}, c\rangle$
- ✕ $\langle\{d, d \to b, a\}, b\rangle$
- ✕ $\langle\{\neg b, e \neg b \wedge e \to f\}, f\rangle$
- ✓ $\langle\{a\}, a\rangle$
- ✕ $\langle\{d \to b\}, b\rangle$
- ✓ $\langle\{d, e, d \to \neg b, \neg b \wedge e \to f\}, f\rangle$

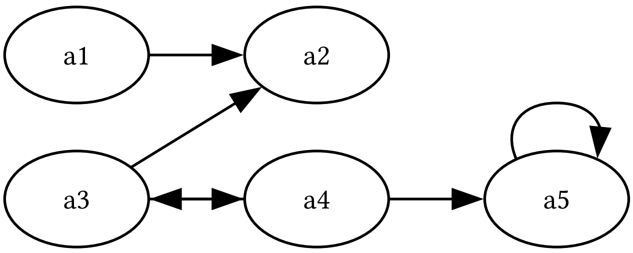
Consider the arguments:

- $\text{arg}_1 = \langle\{a, b, a \wedge b \to c\}, c\rangle$
- $\text{arg}_2 = \langle\{d, d \to \neg b\}, \neg b\rangle$
- $\text{arg}_3 = \langle\{g, g \to \neg c\}, \neg c\rangle$

Which of the following statements captures all of the attacks that exist?

- ✕ arg1 rebuts arg3, arg3 rebuts arg1, arg1 undercuts arg2 and arg2 undercuts arg1
- ✓ arg1 rebuts arg3, arg3 rebuts arg1 and arg2 undercuts arg1
- ✕ arg1 undercuts arg3, arg3 undercuts arg1 and arg2 undercuts arg1

Consider the following abstract argumentation graph.



Which of the following statements are true?

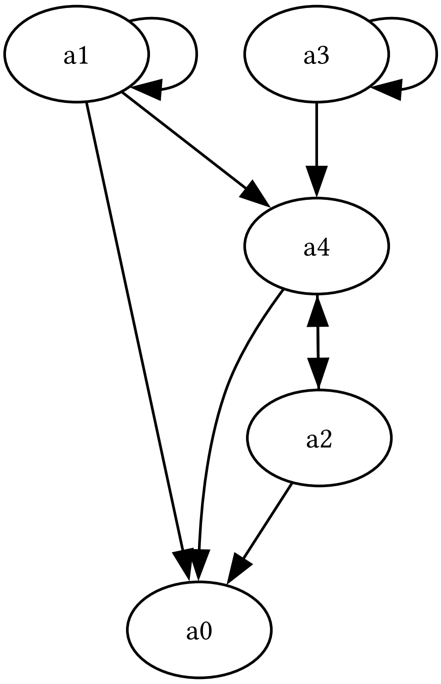
- ✕ There is a labelling under the complete semantics in which a1 is labelled as UNDEC.
- ✓ The only argument labelled as IN under the grounded semantics is a1.
- ✓ There is a labelling under the preferred semantics in which a3 is labelled as IN and a4 is labelled as OUT.
- ✓ There is a labelling under the preferred semantics in which a4 is labelled as IN and a3 is labelled as OUT.
- ✕ There is a labelling under the complete semantics in which a5 is labelled IN.

An abstract argumentation graph consists of argument nodes $\{a_0, a_1, a_2, a_3, a_4\}$ and the following attacks between arguments.

- Argument a1 attacks arguments a0, a1, a4
- Argument a2 attacks arguments a0, a4
- Argument a3 attacks arguments a3, a4
- Argument a4 attacks arguments a0, a2

Under different semantics, the graph may have alternative labellings, where arguments are labelled In, Out, or Undecided. **Which of the following are true?**

- ✓ There is a labelling under the preferred semantics in which argument a2 is In.
- ✕ There is a labelling under the preferred semantics in which argument a0 is In.
- ✕ There is a labelling under the preferred semantics in which argument a3 is In.
- ✕ There is a labelling under the preferred semantics in which argument a1 is Out.
- ✓ There is a labelling under the preferred semantics in which argument a4 is Out.



Under preferred semantics:
a_1 will always be UNDEC
a_3 will always be UNDEC
a_2, a_4 can be IN or OUT
(not UNDEC; preferred is maximal)
a_0 will always be OUT

5. Topic 10

Choose the right words:

When reasoning with argumentation, as an agent gains more knowledge it is possible that it may retract conclusions as well as add them. This is called non-monotonic reasoning and means that the agent can change its position on things.

We can use subjective preferences to resolve two way (symmetric) attacks in argumentation.

Argumentative principles are familiar to humans. This makes argumentation well-suited to supporting explainable AI.

An argument dialogue protocol defines the space of permissible dialogues; an agent uses its private strategy to determine which permissible move to make at any point.

A dialogue of type inquiry allows the agents to jointly reason.

A dialogue of type deliberation is appropriate when the agents need to reach a decision about what to do.

An agent can use its opponent model to strategise in argument dialogues. An opponent model is typically uncertain since agents' internal states are private.

6. January 2016 Paper

Q1ai

		i	
		defect	cooperate
j	defect	-1 -1	2 1
	cooperate	1 2	-1 -1

Figure 1: Payoff Matrix

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]**

A dominant strategy for some agent is one where it doesn't make sense to take any other strategy, they will all result in a lower utility.

For agent i:
- If agent j defects, then it only makes sense to cooperate.
- If agent j cooperates, then it only makes sense to defect (not the same as if they defect).

For agent j:
- If agent i defects, then it only makes sense to cooperate.
- If agent i cooperates, then it only makes sense to defect (not the same as if they defect).

Hence, there is no dominant strategy that can be used here.

Q1aii

		i	
		defect	cooperate
j	defect	-1 -1	2 1
	cooperate	1 2	-1 -1

Figure 2: Payoff Matrix

Explain the notion of a Nash equilibrium and identify any Nash equilibria that exist in the game defined in the payoff matrix above. **[9]**

Nash equilibrium is an outcome where neither agent can improve if they changed their strategy (assuming the other does not change strategy, it is a stable outcome).

In the case they both defect or cooperate, one of the agents can choose to instead cooperate or defect, respectively. Which will improve the utility for both agents.

In the case i defects and j cooperates:
- i defects so j can do no better than to cooperate
- j cooperates so i can do no better than to defect
- Therefore Nash equilibrium

In the case i cooperates and j defects:
- i cooperates so j can do no better than to defect
- j defects so i can do no better than to cooperate
- Therefore Nash equilibrium

So the Nash equilibria are the cases where one agent cooperates and the other defects.

Q1aiii

		i	
		defect	cooperate
j	defect	-1 -1	2 1
	cooperate	1 2	-1 -1

Figure 3: Payoff Matrix

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]**

Pareto optimal outcomes are those in which there are no other outcomes that can make one agent better off without making the other worse off.

For the case they both defect or both cooperate:
- Either agent could instead cooperate or defect, respectively.
- This would result in utilities for both agents increasing.
- Hence this is not a Pareto optimal outcome.

For the case that i defects and j cooperates:
- If i cooperates or j defects, then both their utilites will fall to -1.
- If instead i cooperates and j defects, then i's utility will increase to 2 but j will be worse-off, with their utility falling to 1.
- Hence Pareto optimal outcome.

For the case that i cooperates and j defects:
- If i defects or j cooperates, then both their utilites will fall to -1.
- If instead i defects and j cooperates, then j's utility will increase to 2 but i will be worse-off, with their utility falling to 1.
- Hence Pareto optimal outcome.

So the outcomes that are not Pareto optimal are when they both defect or both cooperate.

Q1aiv
Not in spec.

Q1bi

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

Figure 4: Payoff Matrix for Prisoner's Dilemma

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]**

The dominant strategies are:
- Agent i: always defect as it always gives us a better outcome $2 > 1$ and $4 > 3$
- Agent j: always defect as it always gives us a better outcome $2 > 1$ and $4 > 3$

Suppose agent i plays tit-for-tat and agent j plays dominant strategy:
- Round 1: agent i cooperates and agent j defects (i = 1, j = 4)
- Round 2: agent i defects and agent j defects (i = 2, j = 2)
- Round n: agent i defects and agent j defects (i = 2, j = 2)
- The strategy initially does worse (on first round) but then does just as well as the other agent for all subsequent rounds.

Suppose agent j plays tit-for-tat and agent i plays dominant strategy:
- Round 1: agent j cooperates and agent i defects (j = 1, i = 4)
- Round 2: agent j defects and agent i defects (j = 2, i = 2)
- Round n: agent j defects and agent i defects (j = 2, i = 2)
- The strategy initially does worse (on first round) but then does just as well as the other agent for all subsequent rounds.

Q1bii

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

Figure 5: Payoff Matrix for Prisoner's Dilemma

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]**

If we make the assumption the agent makes no assumptions about the other agent, and there will be at most one interaction, then it is not rational to use the TIT-FOR-TAT strategy as we have no knowledge of the other agent's strategy.

If there are subsequent rounds, it is rational to use TIT-FOR-TAT as it will grant us the biggest payoff in the long-term.

Q2a

Two robots R_1, R_2 are collecting items v_1, v_2, v_3 from a warehouse. All items must be collected and each item is collected by a single robot. Defined as a task-oriented domain as follows:

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

What is a deal for the above scenario? **[4]**

A deal is an allocation of the valuable items to the robots.
For example, a deal $\langle \{v_1\}, \{v_2, v_3\} \rangle$ means:

- Robot R_1 collects v_1 (with cost 3)
- Robot R_2 collects v_2 and v_3 (with cost 12)

Q2b

Two robots R_1, R_2 are collecting items v_1, v_2, v_3 from a warehouse. All items must be collected and each item is collected by a single robot. Defined as a task-oriented domain as follows:

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

List all possible deals for above scenario. **[4]**

$\langle \emptyset, \{v_1, v_2, v_3\} \rangle$
$\langle \{v_1\}, \{v_2, v_3\} \rangle$
$\langle \{v_2\}, \{v_1, v_3\} \rangle$
$\langle \{v_3\}, \{v_1, v_2\} \rangle$
$\langle \{v_1, v_2\}, \{v_3\} \rangle$
$\langle \{v_1, v_3\}, \{v_2\} \rangle$
$\langle \{v_2, v_3\}, \{v_1\} \rangle$
$\langle \{v_1, v_2, v_3\}, \emptyset \rangle$

Q2ci/ii

Two robots R_1, R_2 are collecting items v_1, v_2, v_3 from a warehouse. All items must be collected and each item is collected by a single robot. Defined as a task-oriented domain as follows:

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

Cost function is defined as:

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

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

What is the utility of deal $\delta' = \langle \{v_1\}, \{v_2, v_3\} \rangle$ for robot R_1/R_2? **[4]/[4]**

Utility for R_1 is $3 - 11 = -8$
Utility for R_2 is $12 - 4 = 8$

Q2ciii

Two robots R_1, R_2 are collecting items v_1, v_2, v_3 from a warehouse. All items must be collected and each item is collected by a single robot. Defined as a task-oriented domain as follows:

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

Cost function is defined as:

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

Which of the possible deals are Pareto optimal? **[8]**

Initial encounter is $\langle \{v_1, v_2\}, \{v_3\} \rangle$ — (11, 4)

- ✓ $\langle \emptyset, \{v_1, v_2, v_3\} \rangle$ (0, 15) — (-11, +11)
- ✓ $\langle \{v_1\}, \{v_2, v_3\} \rangle$ (3, 12) — (-8, +8)
- ✓ $\langle \{v_2\}, \{v_1, v_3\} \rangle$ (8, 7) — (-3, +3)
- ✓ $\langle \{v_3\}, \{v_1, v_2\} \rangle$ (4, 11) — (-7, +7)
- ✓ $\langle \{v_1, v_2\}, \{v_3\} \rangle$ (11, 4) — (0, 0)
- ✓ $\langle \{v_1, v_3\}, \{v_2\} \rangle$ (7, 8) — (-4, +4)
- ✓ $\langle \{v_2, v_3\}, \{v_1\} \rangle$ (12, 3) — (+1, −1)
- ✓ $\langle \{v_1, v_2, v_3\}, \emptyset \rangle$ (15, 0) — (+4, −4)

All of the deals are Pareto optimal, as in all of the cases, we can find another outcome that makes one of the agents better off and the other worse off.

Q2ciii

Two robots R_1, R_2 are collecting items v_1, v_2, v_3 from a warehouse. All items must be collected and each item is collected by a single robot. Defined as a task-oriented domain as follows:

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

Cost function is defined as:

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

Which of the possible deals are individually rational? **[8]**

Initial encounter is $\langle \{v_1, v_2\}, \{v_3\} \rangle$ — (11, 4)

- ✗ $\langle \emptyset, \{v_1, v_2, v_3\} \rangle$ (0, 15) — (-11, +11)
- ✗ $\langle \{v_1\}, \{v_2, v_3\} \rangle$ (3, 12) — (-8, +8)
- ✗ $\langle \{v_2\}, \{v_1, v_3\} \rangle$ (8, 7) — (-3, +3)
- ✗ $\langle \{v_3\}, \{v_1, v_2\} \rangle$ (4, 11) — (-7, +7)
- ✓ $\langle \{v_1, v_2\}, \{v_3\} \rangle$ (11, 4) — (0, 0)
- ✗ $\langle \{v_1, v_3\}, \{v_2\} \rangle$ (7, 8) — (-4, +4)
- ✗ $\langle \{v_2, v_3\}, \{v_1\} \rangle$ (12, 3) — (+1, −1)
- ✗ $\langle \{v_1, v_2, v_3\}, \emptyset \rangle$ (15, 0) — (+4, −4)

Only the initial encounter is individually rational as in all other cases, the utility for one of the agents is negative.

Q2cv

Two robots R_1, R_2 are collecting items v_1, v_2, v_3 from a warehouse. All items must be collected and each item is collected by a single robot. Defined as a task-oriented domain as follows:

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

We found that the set of Pareto optimal deals is: $\langle \emptyset, \{v_1, v_2, v_3\} \rangle$, $\langle \{v_1\}, \{v_2, v_3\} \rangle$, $\langle \{v_2\}, \{v_1, v_3\} \rangle$, $\langle \{v_3\}, \{v_1, v_2\} \rangle$, $\langle \{v_1, v_2\}, \{v_3\} \rangle$, $\langle \{v_1, v_3\}, \{v_2\} \rangle$, $\langle \{v_2, v_3\}, \{v_1\} \rangle$, $\langle \{v_1, v_2, v_3\}, \emptyset \rangle$.

We found that the set of individually rational deals is: $\langle \{v_1, v_2\}, \{v_3\} \rangle$.

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

The negotiation set only consists of those deals that are:
- individually rational — there is no point proposing a deal that will make you worse off
- Pareto optimal — there is no point proposing a deal if there is alternative deal that will make at least one agent better off without making the other worse off

So the negotiation set consists of the only item: $\langle \{v_1, v_2\}, \{v_3\} \rangle$

Q2cvi

Two robots R_1, R_2 are collecting items v_1, v_2, v_3 from a warehouse. All items must be collected and each item is collected by a single robot. Defined as a task-oriented domain as follows:

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

We found that negotiation set is: $\langle \{v_1, v_2\}, \{v_3\} \rangle$.

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

Both robots would compute the same negotiation set, as specified above.
The only option is equal to our initial encounter, so the robots have no reason to negotiate further.

The robots stay at the initial deal of $\langle \{v_1, v_2\}, \{v_3\} \rangle$.

There should be a thorough explanation of monotonic concession protocol here!

Q3a
Not in spec.

Q3b
Not in spec.

Q3c
Outline protocol for auction types:
- English **[3]**
- Dutch **[3]**
- First price sealed bid **[3]**
- Vickrey **[3]**

In an English auction, we set an initial (low) price, take ascending bids, until some end point (enough time has passed in which no more bids are placed or a maximum time has been reached).

In a Dutch auction, we set an initial (high) price, the price is lowered in fixed increments, until an agent is bids at the asking price.

In a first price sealed bid auction, all bidders submit their price in private within some time period and the highest bidder wins the auction, there are no subsequent rounds.

In a Vickrey auction, all bidders submit their price in private within some time period and the highest bidder wins the auction but only pays the price of the second-highest bid, there are no subsequent rounds.

Q3d
What is the dominant strategy when participating in a Vickrey auction? Explain why the strategy you have described is dominant. **[10]**

The dominant strategy is to bid your true valuation of the item.
- If you bid more than your true valuation, then you risk potentially paying more than you actually value the item itself. Since now, the second highest bidder could be bidding more than your true valuation, as opposed to less.
- If you bid less than your true valuation, then you don't risk paying more than you value the item but you also risk not getting the item in the first place, if someone values the item more than you and is also playing the dominant strategy. However, if you do get the item, you will still only pay the second highest bid, which in theory has not changed.

Q3e
Consider an auction over a single item with private value. There are four bidding agents (Ag1, Ag2, Ag3 and Ag4). Ag1 values the item at 10, Ag2 values the item at 30, Ag3 values the item at 20 and Ag4 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 Ag2 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 Ag2 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).

- English **[5]**
- Dutch **[5]**
- First price sealed bid **[5]**
- Vickrey **[5]**

English
If all agents act rationally, they will bid until they reach their true valuation and then stop.

If the asking price has not yet reached 20, then Ag2 should bid 20 as Ag3 is expected to drive the price up to this point. This will maximise their utility which will be $30 - 20 = 10$.

If the asking price has reached 20, then Ag2 should bid $20 + \varepsilon$ where ε is the increment in bids. This will result in a utility of $30 - 20 - \varepsilon = 10 - \varepsilon$.

Dutch
If all agents act rationally, they will bid once the asking price drops (or is equal to) their true valuation.

If the agent is risk-averse, they should bid once the asking price reaches $20 + \varepsilon$ where ε is the increment in bids, this will guarantee that they can buy the item before Ag3 places their bid. This will result in a utility of $30 - 20 - \varepsilon = 10 - \varepsilon$.

If the agent is risk-seeking, they should bid once the asking price reaches 20. They may end up with a utility of 0 if Ag3 manages to place their bid first, otherwise their utility will be maximised: $30 - 20 = 10$.

First price sealed bid
If all agents act rationally, they will submit their true valuations.

Ag2 should submit $20 + \varepsilon$ as their bid, where ε is the increment in bids.
This will prevent a conflict in bids and ensure Ag2 wins the auction over Ag3, hence resulting in a utility of $30 - 20 - \varepsilon = 10 - \varepsilon$.

Vickrey
If all agents act rationally, they will submit their true valuations.

Ag2 can submit any bid $V \geq 20 + \varepsilon$, where ε is the increment in bids. This will prevent a conflict in bids and ensure Ag2 wins the auction over Ag3. In a Vickrey auction, we pay the price of the second-highest bidder, hence resulting in a utility of $30 - 20 = 10$.

Q4a
Explain, with aid of examples, the three different aspects of a speech act. **[9]**

- *locutionary act*: act of making the utterance
- *illocutionary act*: conveying of speaker's intentions to the hearer
- *perlocution*: effect achieved by the speech act

Q4b
Describe, with the aid of examples, the following types of speech act **[15]**

- *representatives*: commit speaker to the truth of an expressed proposition
  if I say "it's raining" then my intention is to want you to know I believe it is raining
- *directives*: attempt to get the hearer to do something
  if I say "please make the tea" gives the intention that I want you to make the tea
- *commissives*: commit speaker to some course of action
  if I say "I promise to pay you back next week" gives the intention that I want you to believe that I will pay you back next week
- *expressives*: express some mental state
  if I say "thank you for making the tea" then I want you to believe that I am grateful to you for having made the tea
- *declarations*: bring about some changes in an institutional state of affairs
  things, in appropriate context, that directly affect state of the world in a specific way
  e.g. '[we the jury] find the defendant to be guilty', declaration of war, etc

Q4c

INCOMPLETE

Q5a
Briefly explain how winner is decided under plurality, instant runoff, Borda count, and Copeland rule. **[16\4]**

All of these assume we have a voter profile which is the voter's order of preference of candidates.

- Plurality: voter's first choices are accumulated, and the candidate with most votes wins
- Instant runoff: series of mini-elections are held, we find the candidate with least votes held by all voter's first choices who is then voted off, the vote of the voters who voted for the candidate who has been voted off now count towards the next person they voted for that is still in the race. The round is repeated until only one candidate is left.
- Borda count: we count $(m - n)$ votes for each choice in a voter's preference of candidates where m is the total number of candidates and n is the n-th place position (e.g. 1st candidate out of four gets 3 points).
- Copeland rule: all candidates face off in pairwise majority elections, comparing the sum of votes for each candidate across all voters, where they receive 1 point if they win, −1 point if they lose, and 0 if they draw. The winner is the candidate with the greatest number of points.

Q5b
- 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 **[4]**

  $A = 10, B = 20, C = 30, D = 40$ **D is the winner**.

- Instant runoff **[4]**

  $A = 10, B = 20, C = 30, D = 40$ Least votes in first round go to A.
  $B = 20, C = 30, D = 50$ Least votes in second round go to B.
  $C = 50, D = 50$ **Draw between C and D!**

- Borda count **[4]**

  Vote spread:
  - $A = 1(20) + 1(30) + 2(40) + 3(10) = 160$
  - $B = 3(20) + 2(30) + 1(40) + 1(10) = 170$ **B is the winner.**
  - $C = 2(20) + 3(30) + 0(40) + 0(10) = 130$
  - $D = 0(20) + 0(30) + 3(40) + 2(10) = 140$

- Copeland rule **[4]**

  Pairwise majority elections:
  - (A, B): 50:50 $\longrightarrow$ 0,0
  - (A, C): 50:50 $\longrightarrow$ 0,0
  - (A, D): 60:40 $\longrightarrow$ 1,-1
  - (B, C): 70:30 $\longrightarrow$ 1,-1
  - (B, D): 50:50 $\longrightarrow$ 0,0
  - (C, D): 50:50 $\longrightarrow$ 0,0

  $\therefore A = 1, B = 1, C = -1, D = -1$
  Draw between A and B!

Q5c

- 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. **[4]**

- $A \succ B$: 6:5 therefore holds
- $A \succ C$: 6:5 therefore holds
- $B \succ C$: 9:2 therefore holds

So $A \succ B, C$ and $B \succ C$, $\therefore$ $\boldsymbol{A}$ **is the Condorcet winner.**

Q5d

PSR at the end!

7. January 2017 Paper

Q1a

What are the main properties of an intelligent agent? Make sure you explain what is meant by each of these properties. **[4]**

- **autonomous**: decide for themselves what to do
- **self-interested**: act so as to try to achieve their goals
- **cooperative**: can interact with other agents

Q1bi/ii

Five ongoing trends in computing that have played an important part in leading to the development of the field of multi-agent systems are: ubiquity, interconnection, intelligence, delegation, human-orientation.

I don't think these will come up, none of these have come up in content.

1. Explain what is meant by each of these computing trends. **[5]**

- Ubiquity refers to the fact that computing devices are becoming increasingly pervasive and embedded in our environment
- Interconnection refers to the increasing connectivity and networking of computing devices
- Intelligence refers to the development of systems that can reason, learn, and solve problems
- Delegation is the concept of assigning tasks or goals to agents, allowing for more complex and automated systems
- Human-orientation is the idea of designing systems that are more user-friendly and responsive to human needs

2. Explain how these trends have influenced the development of the field

of multi-agent systems. **[7]**

- Ubiquity has led to the need for agents that can operate in a wide variety of environments and devices. This has created a demand for multi-agent systems that can coordinate and interact with each other in complex and distributed settings.
- Interconnection has made it possible for agents to communicate and collaborate with each other more easily. This has enabled the development of multi-agent systems that can work together to solve complex problems that would be difficult for a single agent to address.
- Intelligence has allowed for the development of more sophisticated agents that can reason, learn, and adapt to changing circumstances. This has made it possible to build multi-agent systems that can make decisions and solve problems more effectively.
- Delegation has led to the need for agents that can take on tasks and goals and work towards achieving them without constant human intervention. This has created a demand for multi-agent systems that can be used to automate complex tasks and processes.
- Human-orientation has influenced the design of multi-agent systems to be more user-friendly and responsive to human needs. This has resulted in multi-agent systems that can interact with humans more intuitively and effectively.

Q1c

Give an example of an application that would be well suited to being implemented as a multi-agent system and explain why this is the case, making reference to the properties you gave for part 1a. (Your example does not have to be an application that exists already; rather it should address a problem that is suited to the multi-agent system approach.) **[7]**

Suppose a set of robots whose goal is to an explore an area for resources within which it is not possible to control the robots from a central hub. The robots could in this case be assigned a set of goals which they are interested in achieving, such as find a resource, they can cooperate with other robots to let them know what areas they've explored so they can collaboratively build a map of the area and its resources.

The robots act autonomously, i.e. they each plan to reach goals independently given the knowledge they've accrued of the environment.

Here's an AI example:

An application that would be well-suited to being implemented as a multi-agent system is a system for managing a smart city's transportation network

- Autonomy: Each agent, representing a vehicle, traffic light, or pedestrian, can make its own decisions about how to navigate the transportation network, reacting to changes in the environment. This autonomy allows for a more flexible and adaptive system that can respond to unexpected events such as accidents or traffic jams.
- Self-interest: Each agent acts in its own self-interest to achieve its goals, such as reaching its destination as quickly as possible, while also taking into account the goals of other agents in the system. For example, a vehicle agent will choose the route it believes is the fastest while a traffic light agent will try to optimize traffic flow, and agents may negotiate to coordinate their actions.
- Intelligence: The agents can use their knowledge of the transportation network and their own goals to make intelligent decisions about how to act. The agents can use AI to learn from past data and improve their performance over time. For example, traffic lights can learn to adapt their timing to the flow of traffic, and vehicle agents can learn the best routes to take based on historical data.
- Multi-agent interaction: The agents in this system need to be able to interact with each other to achieve their goals. For example, vehicles need to be able to communicate with each other to avoid collisions and traffic lights need to be able to communicate with each other to optimize traffic flow. The agents will require the ability to cooperate, coordinate, and negotiate with each other to successfully interact.

This problem is suited to the multi-agent system approach due to the need for a distributed, adaptive, and intelligent system to manage the complex and dynamic nature of a transportation network. It can benefit from the ability of agents to interact and coordinate with each other to achieve a common goal. This kind of system can be implemented to manage traffic flow, reduce congestion, and improve the overall efficiency of the transportation network, which benefits all the users of the system.

Q1di/ii

INCOMPLETE

Q2a
Explain what is meant if we say a deal is individual rational. **[2]**

The deal does not hold any negative utility for either agent, i.e. one or both agents stand to gain something from taking some individually rational deal over the conflict deal.

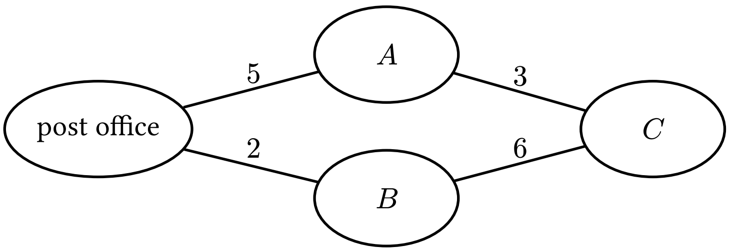
A deal is said to be individual rational if neither agent prefers the conflict deal to that deal.

Q2b
Explain what is meant if we say a deal is Pareto optimal. **[2]**

All other deals that could be taken instead of this deal make one or more agents better off while making other agents worse off.

Different wording: a deal is said to be Pareto optimal if there is no other possible deal where one agent is better off and no agent is worse off.

Q2c
The postal domain is defined with two workers P_1, P_2 who start at the post office. They must deliver post to houses at A, B, C. The cost of delivering to a set of houses is the minimum distance that must be travelled to visit each house in the set and return to the post office.



Initial task allocation is $\langle \{A, B\}, \{C\} \rangle - (9, 8)$.

For every possible deal δ in the postal domain:

1. Give the cost of δ to each postal worker
   $\langle \{A\}, \{B, C\} \rangle$ have costs $P_1 = 5, P_2 = 8$
   $\langle \{B\}, \{A, C\} \rangle$ have costs $P_1 = 2, P_2 = 8$
   $\langle \{C\}, \{A, B\} \rangle$ have costs $P_1 = 8, P_2 = 9$
   $\langle \{B, C\}, \{A\} \rangle$ have costs $P_1 = 8, P_2 = 5$
   $\langle \{A, C\}, \{B\} \rangle$ have costs $P_1 = 8, P_2 = 2$
   $\langle \{A, B\}, \{C\} \rangle$ have costs $P_1 = 9, P_2 = 8$
2. Give the utility of δ to each postal worker
   $\langle \{A\}, \{B, C\} \rangle$ have utility $P_1 = 4, P_2 = 0$
   $\langle \{B\}, \{A, C\} \rangle$ have utility $P_1 = 7, P_2 = 0$
   $\langle \{C\}, \{A, B\} \rangle$ have utility $P_1 = 1, P_2 = -1$
   $\langle \{B, C\}, \{A\} \rangle$ have utility $P_1 = 1, P_2 = 3$
   $\langle \{A, C\}, \{B\} \rangle$ have utility $P_1 = 1, P_2 = 6$
   $\langle \{A, B\}, \{C\} \rangle$ have utility $P_1 = 0, P_2 = 0$
3. Say whether δ is individually rational
4. Say whether δ is Pareto optimal

Q3ai/ii/iii/iv

- 80 voters: $D \succ C \succ B \succ A$
- 60 voters: $A \succ B \succ D \succ C$
- 50 voters: $C \succ B \succ D \succ A$
- 30 voters: $A \succ C \succ B \succ D$

What is the outcome when following each of the following?

1. Plurality **[3]**

   $A = 90, B = 0, C = 50, D = 80$ ***A* is the winner.**

2. Instant runoff **[3]**

   $A = 90, B = 0, C = 50, D = 80$ Least votes to B.
   $A = 60, C = 50, D = 80$ Least votes to C.
   $A = 90, D = 110$ Least votes to A, ***D* is the winner.**

3. Borda count **[3]**

   $A = 0(80) + 3(60) + 0(50) + 3(30) = 270$
   $B = 1(80) + 2(60) + 2(50) + 1(30) = 330$
   $C = 2(80) + 0(60) + 3(50) + 2(30) = 270$
   $D = 3(80) + 1(60) + 1(50) + 0(30) = 350$ ***D* is the winner.**

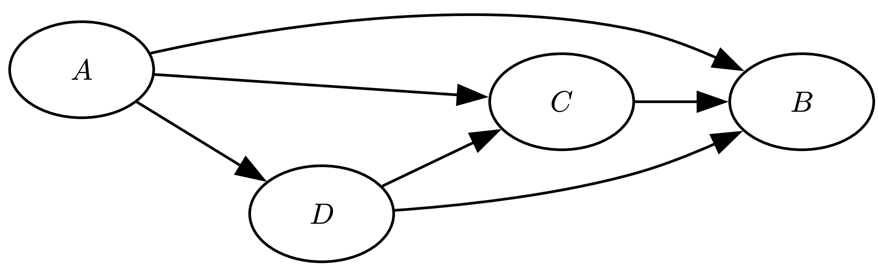
4. Copeland rule **[3]**

   Pairwise majority elections:
   (A, B): 90:130 ⟶ −1,1
   (A, C): 90:130 ⟶ −1,1
   (A, D): 90:130 ⟶ −1,1
   (B, C): 60:160 ⟶ −1,1
   (B, D): 140:80 ⟶ 1,-1
   (C, D): 80:140 ⟶ −1,1
   A = −3, B = 1, C = 1, D = 1   **It's a draw between B, C, D!**

Q3bi/ii

- Voter 1: $D \succ C \succ B \succ A$
- Voter 2: $A \succ B \succ D \succ C$
- Voter 3: $A \succ C \succ D \succ B$

Draw the majority graph **[2]** and identify the Condorcet winner if one exists, otherwise explain why one does not exist **[2]**.



The Condorcet winner is A as it is always preferred.

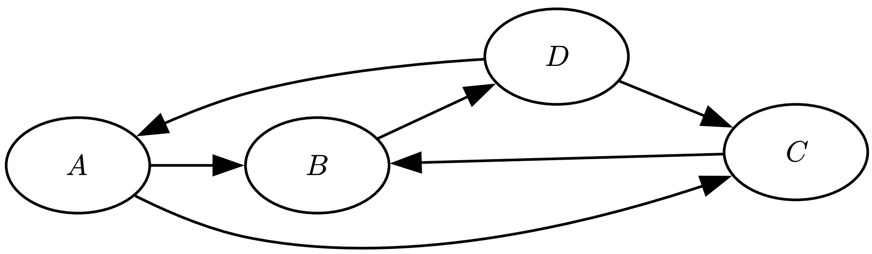
Q3ci/ii

- Voter 1: $A \succ C \succ B \succ D$
- Voter 2: $D \succ A \succ C \succ B$
- Voter 3: $B \succ D \succ A \succ C$

A linear sequence of pairwise majority elections are planned.

Give an agena that will ensure A **[4]** / D **[4]** is the overall winner.

Begin by drawing the majority graph:



- To ensure A wins: D, C, B, A; $D \succ C, B \succ D, A \succ B$
- To ensure D wins: B, C, A, D; $C \succ B, A \succ C, D \succ A$

Q3d

Explain what it means if a voting procedure satisfies the independence of irrelevant alternatives condition. **[2]**

This means that for any given two candidates, if $A \succ B$, then A will always $\succ B$ even if other candidates are favoured differently.

Outcome of an election between two candidates depends only on how voters rank those two candidates, and is unaffected by how voters rank other, irrelevant candidates.

Q3e

- Alice: $B \succ C \succ A \succ D$
- Bob: $C \succ B \succ A \succ D$
- Charlie: $D \succ C \succ B \succ A$

They decide to hold a vote according to Borda count rule, with ties decided randomly.
In whose interest is it to vote strategically and falsely report their preference (assuming they know truthful preferences of other two voters)? Specify the person as well as ordering they should report instead of their true preference. Show working. **[7]**

Q4ai/ii

Knowledge that an agent has about films, X is a variable that can be instatiated by any constant, and all constants start with lower-case letters.

- NinetiesFilm(homealone)
- ActionFilm(homealone)
- NinetiesFilm(X) ∧ ActionFilm(X) → ¬ Watch(X)
- DirectedBy(johnhughes, homealone)
- DirectedBy(johnhughes, X) → Watch(X)
- DirectedBy(johnhughes, X) → ¬ ActionFilm(X)

Using the knowledge above, it is possible to construct two arguments that rebut one another. Identify two such arguments, giving the support and the claim of each. **[4]**

One can construct the arguments:
- $\langle\{\mathrm{NinetiesFilm(homealone)}, \mathrm{ActionFilm(homealone)}, \mathrm{NinetiesFilm(X)} \land \mathrm{ActionFilm(X)} \to \neg\ \mathrm{Watch(X)}\}, \neg\ \mathrm{Watch(X)}\rangle$
- $\langle\{\mathrm{DirectedBy(johnhughes,\ homealone)}, \mathrm{DirectedBy(johnhughes,\ X)} \to \mathrm{Watch(X)}\}, \mathrm{Watch(X)}\rangle$

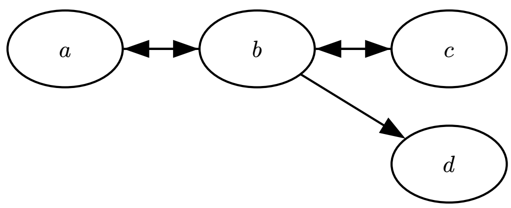
Both arguments rebut each other, stating the agent both should/shouldn't watch Home Alone.

Using the knowledge above, it is possible to construct two arguments such that one undercuts the other. Identify two such arguments, giving the support and the claim of each. Make it clear in your answer which argument undercuts the other. **[4]**

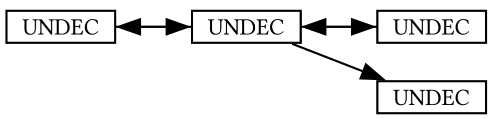
One can construct the arguments:
- $\langle\{\mathrm{NinetiesFilm(homealone)}, \mathrm{ActionFilm(homealone)}, \mathrm{NinetiesFilm(X)} \land \mathrm{ActionFilm(X)} \to \neg\ \mathrm{Watch(X)}\}, \neg\ \mathrm{Watch(X)}\rangle$
- $\langle\{\mathrm{DirectedBy(johnhughes,\ homealone)}, \mathrm{DirectedBy(johnhughes,\ X)} \to \neg\ \mathrm{ActionFilm(X)}\}, \neg\ \mathrm{ActionFilm(homealone)}\rangle$

The second argument rebuts the claim ActionFilm(homealone), hence undercuts the first argument.

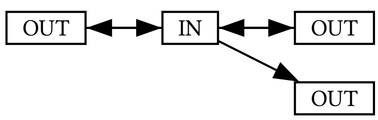
Q4b

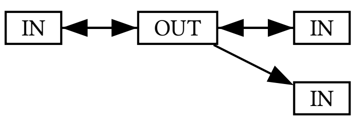


- Give all valid labellings under grounded semantics. **[4]**



- Give all valid labellings under preferred semantics **[6]**





7 January 2017 Paper

INCOMPLETE

8. January 2018 Paper

Q1a

INCOMPLETE this is just a VCG Q, skipped to save time

Q1b

INCOMPLETE pretty straightforward bidding Q? skipped for time

Q1c

Winner's curse is not covered in the spec.

Q2a

INCOMPLETE skipped for time, relatively simple reasoning?

Q2b

```
B := B0; /? B0 is initial value of B ?/
I := I0; /? I0 is initial value of I ?/
while true do
  get next percept ρ;
  B:= brf(B, ρ);
  D:= options(B, I);
  I:= filter(B, D, I);
  π:= plan(B, I);
  while not empty(π) do
    α:= hd(π);
    execute(α);
    π:= tail(π);
    get next percept ρ;
    B:= brf(B, ρ);
    if not sound(π, I, B) then
      π:= plan(B, I);
    end-if
  end-while
end-while
```

Identify any situations in which you think this agent would not behave optimally, making reference to the pseudo-code to explain your answer. **[6]** Explain clearly how you would modify the pseudo-code in order to improve the agent's performance. **[6]**

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Q2c

INCOMPLETE

Q3

Q4a

Q4b

Q4c

9. Positional Scoring Proof

2016 Q5d

Suppose (s_1, s_2, s_3) is an arbitrary Positional Scoring Rule where s_1, s_2, s_3 are positive whole numbers such that $s_1 \geq s_2 \geq s_3$ and $s_1 > s_3$.

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: $C \succ A \succ B$

Show that this voting rule does not select the Condorcet winner. **[14]**

The Condorcet winner is **A**:
- A, B: 6,5 $\therefore A \succ B$
- A, C: 6,5 $\therefore A \succ C$
- B, C: 9,2 $\therefore B \succ C$

Begin by formalising the voter profile:
- $\text{score}(A) = 4s_1 + 4s_2 + 3s_3$
- $\text{score}(B) = 5s_1 + 4s_2 + 2s_3$
- $\text{score}(C) = 2s_1 + 3s_2 + 6s_3$

We use the intuition that we expect $\text{score}(B) - \text{score}(A) < 0$ and likewise for C and A.
Compare expected loser B with expected winner A:

$$\begin{aligned}\text{score}(B) - \text{score}(A) &= (5s_1 + 4s_2 + 2s_3) - (4s_1 + 4s_2 + 3s_3) \\ &= s_1 - s_3\end{aligned}$$

$$\begin{aligned}\text{score}(B) - \text{score}(A) &< 0 \\ \therefore s_1 - s_3 &< 0\end{aligned}$$

However, we know that $s_1 > s_3$, which tells us that $s_1 - s_3 > 0$.
This is a **contradiction**! Therefore the positional scoring rule does **not** select the Condorcet winner.