i COMPSCI 367 Cover Page

COMPSCI 367

THE UNIVERSITY OF AUCKLAND

SEMESTER TWO, 2022
Campus: Online exam

COMPUTER SCIENCE

Artificial Intelligence

Time Allowed: 2 hours and 30 min additional time

NOTE:

- Answer All questions.
- Some are worth more than others.
- Most questions are multiple choices, matching or multiple answers questions.
- The four last questions are text entry.
- Some questions might have multiple sub-questions on the same page. Make sure you scroll down to find all the questions.
- Some questions have an illustration on the left, and the question on the right for more readability when you answer.
- This is an open book exam, but you must not under any circumstances collaborate on the answers with other class members or other people.
- This Exam is worth 45% of your final grade.

i Academic Integrity Statement 1225

By submitting this assessment, I agree to the following declaration:

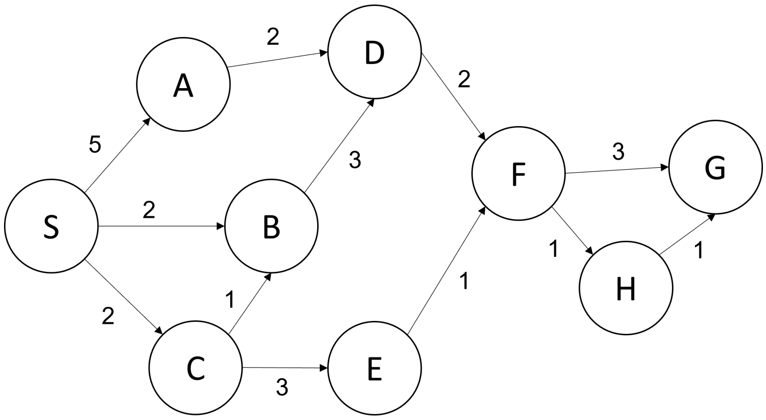
As a member of the University’s student body, I will complete this assessment with academic integrity and in a fair, honest, responsible, and trustworthy manner. This means that:

- I will not seek out any unauthorised help in completing this assessment. Unauthorised help includes, but is not limited to, asking another person, friend, family member, third party, tutorial, search function or answer service, whether in person or online.
- I will not discuss or share the content of the assessment with anyone else in any form during the assessment period, including but not limited to, using a messaging service, communication channel or discussion forum, Canvas, Piazza, Chegg, third party website, Facebook, Twitter, Discord, social media or any other channel within the assessment period.
- I will not reproduce and/or share the content of this assessment in any domain or in any form where it may be accessed by a third party.
- I will not share my answers or thoughts regarding this assessment in any domain or in any form within the assessment period.
- I am aware the University of Auckland may use Turnitin or any other plagiarism detecting methods to check my content.
- I declare that this assessment is my own work, except where acknowledged appropriately (e.g., use of referencing).
- I declare that this work has not been submitted for academic credit in this or another University of Auckland course, or elsewhere.

I understand the University expects all students to complete coursework with integrity and honesty. I promise to complete all online assessment with the same academic integrity standards and values.

Any identified form of poor academic practice or academic misconduct will be followed up and may result in disciplinary action.

I confirm that by completing this exam I agree to the above statements in full.



Node	**h**
S	7
A	6
B	6
C	5
D	4
E	3
F	2
H	1
G	0

1 Search algorithms 1/2

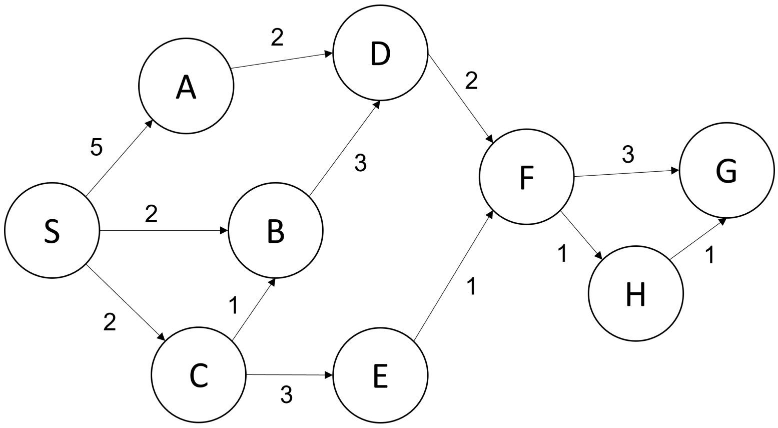
Given the state graph and heuristic table on the left, pair each search algorithm with the corresponding list of expanded nodes.

Lists of expanded nodes:
A: S,C,E,F,G
B: S,C,B,E,F,H,G
C: S,A,B,C,D,D,B,E,F,F,D,F,G
D: S,B,C,B,A,D,E,D,F,D,F,H,F,G
E: S,S,A,B,C,S,A,D,B,D,C,B,E,S,A,D,F,B,D,F,C,B,D,E,F,S,A,D,F,G
F: S,A,D,F,G

Please match the values:

	A	F	B	E	D	C
Breadth First tree search	○	○	○	○	○	○
Uniform cost tree search	○	○	○	○	○	○
Iterative Deepening tree search	○	○	○	○	○	○
Greedy best first tree search	○	○	○	○	○	○
A* tree search	○	○	○	○	○	○
Depth First tree search	○	○	○	○	○	○

Maximum marks: 4.5



Node	h
S	7
A	6
B	6
C	5
D	4
E	3
F	2
H	1
G	0

2 Search algorithms 2/2

Given the state graph and heuristic table on the left, which of the following sentences are True?
Select one or more alternatives:

- ☐ A*, UCS and Greedy return the optimal path.
- ☐ The optimal path is S,C,E,F,H,G.
- ☐ A*, UCS and BFS return the optimal path.
- ☐ The optimal path is S,A,D,F,G.
- ☐ A* and UCS return the optimal path.
- ☐ The optimal path is S,C,E,F,G.

Maximum marks: 1

3 Informed search

If you ran wA* with w=0, what algorithm would this be the most equivalent to?
Select one alternative:

- Branch and Bound search
- Uniform Cost Search
- Greedy search
- Depth-First search
- A* search

Maximum marks: 1

4 Bidirectional search

Which of the following is not true?
Select one alternative:

- Given a problem and heuristics h1 & h2 where h2 dominates h1, GBFHS could not expand more nodes using h2 than when using h1.
- GBFHS's first solution for unit-cost domain problem is guaranteed to be optimal.
- A* always expand less nodes than GBFHS.
- Front-to-end heuristics are almost always used in bidirectional search .
- In GBFHS, the choice of which frontier to expand is made through the split function.

Maximum marks: 1

5 Bubble Puzzle

For the bubble puzzle, if you are in the starting state: << RRBG >,< GGB >,< GR >,< BB >,< R >> and assuming the top of the bottle is **on the right** and the heuristic is $h = \sum_{i=1}^{B} max(0, \#C(i) - 1)$, where $\#C(i)$ is the number of colours in bottle *i*, and *B* is the total number of bottles. In English this means, “the number of colours in each bottle -1, summed over all the bottles, and when there is only 1 colour or 0 colours the heuristic returns 0 for that bottle”. So the heuristic of the starting state is 2+1+1+0+0=4. Assume each bottle can only hold 4 bubbles.

Among the following states, which one is a possible state returned by greedy descent (hill-climbing with minimisation) run on the starting state with heuristic *h* ?

Select one alternative:

- << RR >,< GGG >,< GR >,< BBB >,< RB >>
- << RRB >,< GGG >,< GR >,< BBB >,< R >>
- << RRBR >,< GGB >,< GRG >,< BB >,< R >>
- << RRRR >,< GGGG >,< >,< BBBB >,< >>
- << RRR >,< GGG >,< G >,< BBBB >,< R >>

Maximum marks: 1.5

6 Logic 1

The following formula states that if a cat is a feline and a feline is a mammal, then a cat is a mammal, with P = "a cat is a feline", Q = "a feline is a mammal" and R = "a cat is a mammal".
$P \land Q \implies R$

Which level of expressivity of logic is required for this formula?
Select one alternative:

- Probabilistic logic
- First order logic
- Second order logic
- Propositional logic

Maximum marks: 1

7 Logic 2

Are the statements $(A \land B) \implies C$ and $(A \implies C) \land (C \implies B)$ logically equivalent ?
(You can use a truth table.)
Select one alternative:

- False
- True

Maximum marks: 2

8 Entropy

Consider an imaginary language formed of the following vocabulary: "amto", "veha", "ebi", "tryma", "tapru", "vraf", "rodma".

This language is composed of 15 letters: a, m, t, o, v, e, h, b, i, r, y, p, u, f, d.

What is the binary entropy of this language (approximated to 2 decimals)?

Select one alternative:

- -1.61
- 62.85
- 3.61
- -62.85
- -3.61
- 1.61

Maximum marks: 2

9 Translation

The Rosetta stone is a stele, discovered in Egypt in 1799, inscribed with 3 similar versions of a decree in hieroglyphic and Demotic scripts, and in Ancient Greek.

Nobody could read hieroglyphs when it was discovered, but scholars were able to understand Ancient Greek. Through the understanding of the Ancient Greek (ag) part and because the texts are saying almost the same thing, scholars used the stone to help decipher hieroglyphs (hr).

In terms of machine translation and according to the noisy channel model, we can say that the Rosetta stone enabled to estimate:

Select one alternative:

- The translation model p(ag|hr).
- The language model p(ag|hr).
- The language model p(hr|ag).
- The language model p(ag).
- The translation model p(hr|ag).
- The translation model p(ag).

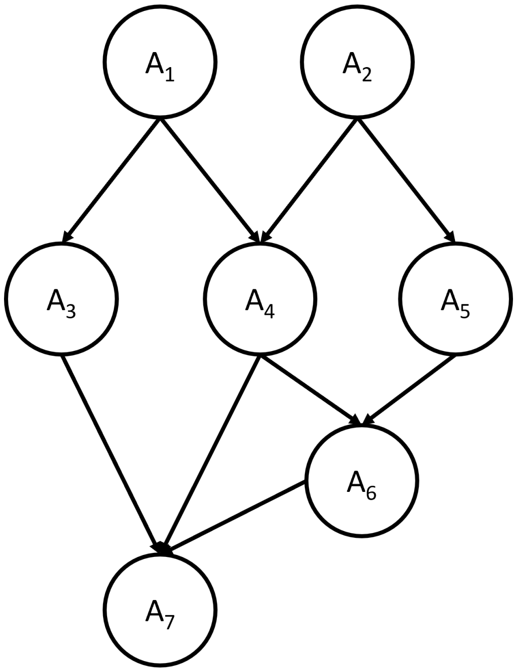
Maximum marks: 1

10 Ontology

Which of the following sentences are true about concepts represented in an ontology?
Select one or more alternatives:

- [ ] The concept of "Action" is likely to be represented in the Upper Ontology.
- [ ] The concept of "PythonProgram" is likely to be represented in the Upper Ontology.
- [ ] The concept of "CookingDiner" is likely to be represented in the Lower Ontology.
- [ ] The concept of "Thing" is likely to be represented in the Middle Ontology.
- [ ] The concept of "TibialShaftFracture" is likely to be represented in the Middle Ontology.
- [ ] The concept of "Action" is likely to be represented in the Lower Ontology.

Maximum marks: 2


A1
A2
A3
A4
A5
A6
A7

11 Bayes Network

Consider the Bayesian Network on the left which represents the following relations between the random variables A_1, A_2, A_3, A_4, A_5, A_6 and A_7:

A_1 and A_2 are marginally independent from each other. A_3 is conditionally dependent to A_1. A_4 is conditionally dependent to both A_1 and A_2. A_3 is conditionally dependent to A_2. A_6 is conditionally dependent to both A_4 and A_5. A_7 is conditionally dependent to A_3, A_4 and A_6.

Assume all random variables are Boolean, they are either ‘true’ or ‘false’.

What is the expression for the joint probability distribution as a product of conditional probabilities?

Select one alternative:

- $P(A_1,A_2,A_3,A_4,A_5,A_6,A_7) = P(A_1)*P(A_2)*P(A_3|A_1)*P(A_4|A_1,A_2)*P(A_5|A_2)*P(A_6|A_4,A_5)*P(A_7|A_3,A_4,A_6)$

- $P(A_1,A_2,A_3,A_4,A_5,A_6,A_7) = P(A_1|A_3,A_4)*P(A_2|A_4,A_5)*P(A_3|A_7)*P(A_4|A_6,A_7)*P(A_5|A_6)*P(A_6|A_7)*P(A_7)$

- $P(A_1,A_2,A_3,A_4,A_5,A_6,A_7) = P(A_1)*P(A_2)*P(A_3)*P(A_4)*P(A_5)*P(A_6)*P(A_7)$

- $P(A_1,A_2,A_3,A_4,A_5,A_6,A_7) = P(A_1|A_2,A_3,A_4,A_5,A_6,A_7)*P(A_2|A_3,A_4,A_5,A_6,A_7)*P(A_3|A_4,A_5,A_6,A_7)*P(A_4|A_5,A_6,A_7)*P(A_5|A_6,A_7$

What is the number of independent parameters that is required to describe this joint distribution given the Bayes Network?

Select one alternative

- 9
- 128
- 22
- 7
- 127

Maximum marks: 4

Language	I	go	to	school	with	a	sandwich	my	is	good	buy	great
English	2	1	1	2	1	2	3	1	2	1	1	1
English+1	3	2	2	3	2	3	4	2	3	2	2	2
$\hat{P}(v_i\|en)$	0.081	0.054	0.054	0.081	0.054	0.081	0.11	0.054	0.081	0.054	0.054	0.054
French	0	0	0	0	0	0	0	0	0	0	0	0
French+1	1	1	1	1	1	1	1	1	1	1	1	1
$\hat{P}(v_i\|fr)$	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032

Language	mon	école	est	je	mange	dans	loin	$\sum$
English	0	0	0	0	0	0	0	18
English+1	1	1	1	1	1	1	1	37
$\hat{P}(v_i\|en)$	0.027	0.027	0.027	0.027	0.027	0.027	0.027	1
French	3	3	2	1	1	1	1	12
French+1	4	4	3	2	2	2	2	31
$\hat{P}(v_i\|fr)$	0.13	0.13	0.097	0.064	0.064	0.064	0.064	1

12 Naive Bayes

The table on the side shows word counts and probability estimates for the following corpus, composed of 7 sentences, 4 in English and 3 in French:
“I go to school with a sandwich”, “My sandwich is good”, “I buy a sandwich”, “School is great”,
“Mon école est super”, “Je mange dans mon école”, “Mon école est loin”.

Why is the count for each word smoothed by adding one before calculating the probability estimates $\hat{P}(v_i \mid en)$ and $\hat{P}(v_i \mid fr)$?
Select one alternative:

- The training set is small and is likely not to be representative of the true probability distributions.
- There is one less sentence in French than English in the training set, so we need to add one to each word count to account for this unbalance.
- The true probability distributions are close to uniform distributions.
- The training set has a low entropy, which could lead to biased estimates.

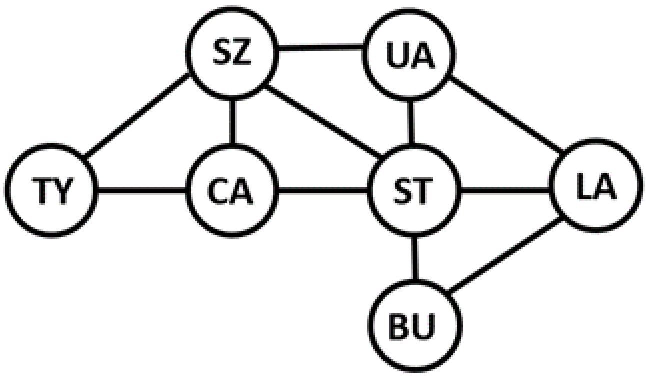
The probabilities of the phrase Q = *"Mon sandwich est good"* being English and French respectively using Naïve Bayes and the probability estimates given are:
Select one alternative

- P(en|Q)=0; P(fr|Q)=0
- P(en|Q)=0.5; P(fr|Q)=0.5
- P(en|Q)=5.53e-6; P(fr|Q)=2.47e-6
- P(en|Q)=2.47e-6; P(fr|Q)=5.53e-6

Maximum marks: 4

13 Constraint Satisfaction Problem

The following graph shows the adjacency of some regions from Austria. You'd like to give a colour from {R,G,B} to each node so that no two adjacent nodes get the same colour.



BU = Burgenland
CA = Carinthia
LA = Lower Austria
ST = Styria
SZ = Salzburg
TY = Tyrol
UA = Upper Austria

We model this problem as a CSP with variables: BU, CA, LA, ST, SZ, TY, UA, whose domains are all {R,G,B} and the constraints indicate that any adjacent nodes would be assigned different values.

1. Starting from the partial assignment *f(LA)=G*, *f(CA)=B*, and assuming the initial domain of all other nodes is {R,G,B}, apply the **arc consistency (AC3) algorithm**. Write down the remaining values in the domain of each node after the algorithm is completed.

2. Starting from the node BU with assignment *f(BU)=R,* apply **the Backtrack-FC algorithm**, where the *Select-Unassigned-Var* operation is implemented using two heuristics: First, apply MRV heuristic to choose a value, and then use the degree heuristic as a tie breaker. *Order-Dom* simply selects the next available value from the temporary domain for the variable in the order: "R" then "G" then "B". Write down, **in the same order as returned by the Backtrack-FC algorithm**, the list of nodes and their assigned colours.

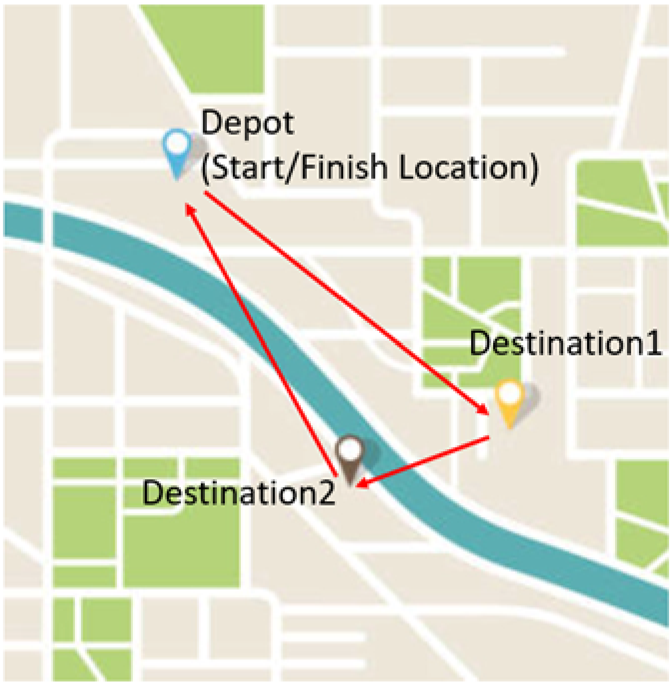
The answers to both questions should be entered into the one textbox at the bottom of the question.

Fill in your answer here

Maximum marks: 4

14 Planning

Consider the following domain for a drone (as shown in the picture below) which flies in a loop. There are three locations that the delivery drone must fly to: from the Depot to Destination 1, from Destination 1 to Destination 2, and from Destination 2 back to the Depot. Note that the delivery drone is initially loaded with a package when it leaves the Depot, which it drops off at Destination 1. The drone takes a photo of Destination 2 before returning to the Depot.



The predicates are as follows:

- *drone(d)*: true if *d* is a drone
- *location(x)*: true if *x* is a location. (The Depot, Destination 1 and Destination 2 are locations.)
- *package(p)*: true if *p* is a package.
- *at(i, x)*: true if item *i* is at location *x*. (The item, *i*, could potentially be a drone or a package.)
- *in(p, d)*: true if the package *p* is in drone *d*.
- *photo(x)*: true if a photo has been taken at location *x*.

The actions of the drone include flying from location to location, dropping off a package at a location, and taking a photo of a location.

- *fly(d,x,y)*: **requires** that the drone is at location *x*. **The action** places the drone at location *y* (and, hence, the drone is no longer at location *x*).
- *dropOff(p,d,x)*: **requires** that package, *p*, is in the drone, *d*. Also, the drone must be at location *x*. **The action** puts the package at location *x*. The package is also no longer in the drone.
- *takePhoto(d,x)*: **requires** that the drone is at location *x*. **The action** takes a photo at location *x*.

Write a **PDDL description of this planning domain**. You need to use the PDDL syntax starting from the following:

(define (domain delivery)

(:requirements :strips)

(:predicates (drone ?d) (location ?x) (package ?p) (at ?i ?x) (in ?p ?d) (photo ?x))

…***//fill in the description here//***

)

Fill in your answer here

Maximum marks: 6

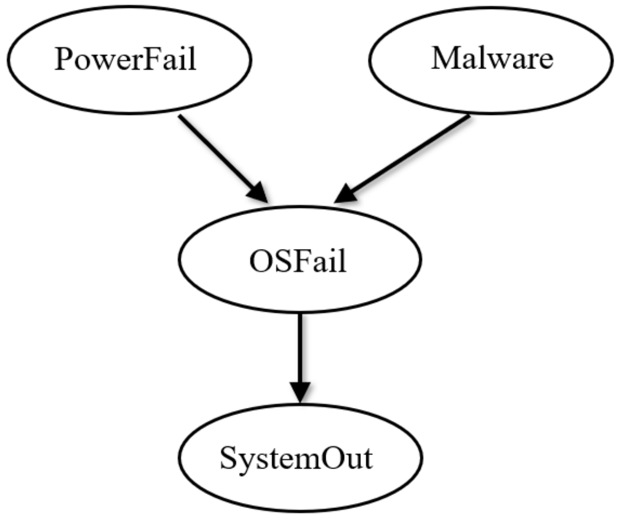
15 Uncertainty

We are in a team supporting a large network of computers. We are writing an app for our users to troubleshoot the likely cause of system outages.

A system outage may occur when there is an operating system failure. An operating system might fail due to a power failure—perhaps resulting in an operating system malfunction—or else due to malware infecting the network.

We construct the following Bayesian network containing 4 atoms:

1. **PowerFail** is true if and only if there is a power failure.
2. **Malware** is true if and only if malware has infected the system.
3. **OSFail** is true if and only if the operating system fails.
4. **SystemOut** is true if and only if there is a system outage.



1. Consider the following scenario. Let's say you find that there is a system outage. There has been no power failure recorded. But the operating system has crashed. What are the observed variables and their values in this scenario?

2. A user is now investigating an operating system failure. The table below gives the probability distribution *P*(OSFail | PowerFail, Malware). Suppose *P*(Malware)=0.1 and *P*(PowerFail)=0.2. Given that the operating system has failed, compute the probability that this is due to malware infecting the system. Detail the procedure you use to solve this problem using the **variable elimination algorithm** and state your conclusion.

PowerFail	Malware	**OSFail**	Probability
True	True	True	1
True	True	False	0
True	False	True	0.5
True	False	False	0.5
False	True	True	0.5
False	True	False	0.5
False	False	True	0
False	False	False	1

The answers to both questions should be entered into the one textbox at the bottom of the question.

Fill in your answer here

Maximum marks: 5

16 Decision

Consider a traveller who is thinking about the type of airline ticket to buy for their trip. She has the choice of paying the standard ticket price or instead to purchase a heavily-discounted “Big Deal” ticket. The “Big Deal” ticket can be used ony if there are empty seats available on the plane after other passengers have completed flight check-in. However, there is a chance that there will be no available seats for the flight and, if so, she will have to catch a later flight. Luckily, she has a friend who works for the airline who can check the flight details and predict whether there are likely to be seats available (though sometimes the friend gets it wrong).

The traveller would like to construct a decision network to inform the decision. The decision network includes a single decision node and two chance nodes.

Chance node: Flight : {spare, full}, FriendPredict : {predspare, predfull}

Decision node: BuyBigDeal : {0, 1}.

Flight	*P(Flight)*
spare	0.6
full	0.4

Flight	**BuyBigDeal**	*u(Flight,BuyBigDeal)*
spare	1	500
spare	0	-50
full	1	-800
full	0	50

Flight	**FriendPredict**	*P(FriendPredict | Flight)*
spare	predspare	0.7
spare	predfull	0.3
full	predspare	0.2
full	predfull	0.8

1. Construct the decision network for this problem. In the textbox, list all the directed edges in the decision network.

Note: An edge from node x to node y can be written as (x,y).

2. For each of the possible predictions by the friend (*predspare, predfull*), compute the expected utilities for the traveller of buying a “Big Deal” ticket and not buying this ticket (i.e., paying the standard ticket price).

3. For each of the possible predictions by the friend (*predspare, predfull*), what is the best ticket option for the traveller?

The answers to all questions should be entered into the one textbox at the bottom of the question.

Fill in your answer here

Maximum marks: 5