JOHN MONASH SCIENCE SCHOOL

VICTORIAN CERTIFICATE OF EDUCATION

2021

ALGORITHMICS (HESS)

Practice Exam

2021

SOLUTIONS

SECTION A – Multiple-choice Questions

Question	%A	%B	%C	%D	%No Answer	Comments
1	5	89	0	5	0	Correct Answer : B
2	5	0	0	95	0	Correct Answer : D
3	16	0	79	5	0	Correct Answer : C
4	0	0	0	100	0	Correct Answer : D
5	26	0	63	11	0	Correct Answer : C
6	53	16	0	32	0	Correct Answer : A
7	5	0	5	89	0	Correct Answer : D
8	5	63	11	21	0	Correct Answer : B
9	0	0	100	0	0	Correct Answer : C
10	37	11	11	37	5	Correct Answer : D
11	0	5	79	16	0	Correct Answer : C
12	11	74	0	11	5	Correct Answer : B
13	21	74	5	0	0	Correct Answer : B
14	11	5	79	0	5	Correct Answer : C
15	42	5	37	16	0	Correct Answer : A
16	0	79	16	5	0	Correct Answer : B
17	21	5	68	0	5	Correct Answer : C
18	0	11	68	21	0	Correct Answer : C
19	0	0	100	0	0	Correct Answer : C
20	11	53	32	5	0	Correct Answer : B

SECTION B

SECTION B

Question 1 (4 marks)

Darcy is fed up with PyNode and wants to write his own version of the program so that he can usurp Alex Socha and become immortalised in the JMSS Algorithmics Hall of Fame.

Write a complete signature specification for the Graph ADT.

Marks	0	1	2	3	4	Average
%	13	13	13	6	56	**2.81**

Below is an example of a high scoring response to this question:

```
newGraph:   → graph

addNode: graph x element → graph
addEdge: graph x element x element → graph

adjacent:graph x element x element → boolean
neighbours: graph x element → List
```

Inclusion of the newGraph constructor (or equivalent)	A1
Inclusion of the addNode constructor (or equivalent)	A2
Inclusion of the addEdge constructor (or equivalent)	A3
Inclusion of the some correct observer (such as adjacent or neighbours or similar)	A4

Question 2 (5 marks)

Mr Corkill is planning a special event in 2022 for those students at JMSS who have missed their formals in 2021 due to lockdown. Students will be allowed to bring one additional person to the event but Mr Corkill needs a way to keep track of how many tickets each student is purchasing.

He decides to ask Valerii for assistance.

a. Name an appropriate ADT that Valerii could use and how it would model the relevant information for Mr Corkill. 3 marks

Marks	**0**	**1**	**2**	**3**	**Average**
%	13	0	0	88	**2.63**

Below is an example of a high scoring response to this question:

He could use the Dictionary ADT where the key represents the name of the student and the associated value is the number of tickets that student needs

Identification of appropriate ADT (Dictionary, Priority Queue, Array or list of lists)	A1
Attempt to explain how the ADT would model the information is incomplete or contains a minor error	A2
Accurate explanation of how the ADT could model the information	A3

Mr Corkill realises that he will also need to keep track of whether a student has paid for the tickets and who will be picking up the tickets.

b. Explain what changes Valerii will need to make to the ADT chosen in **part a.** in order to be able to keep track of the extra information. 2 marks

Marks	**0**	**1**	**2**	**Average**
%	31	13	56	**1.25**

Below is an example of a high scoring response to this question:

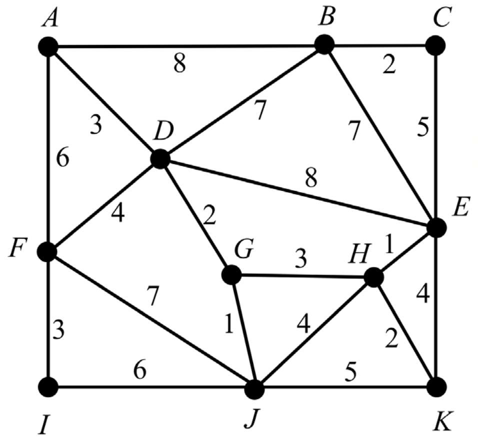
The value in the Dictionary ADT key-value pair could be changed to be a list that contains the number of tickets required, a true or false statement regarding if they have paid or not and the name of the person who will be picking up the tickets.

Correct identification of a change that could be made to the ADT (value changed to list)	A1
Specific information about how the new information would be incorporated is provided.	A2

Question 3 (8 marks)

Sukhman and Jordan spent a large part of the school holidays thinking about their futures and what they wanted to do after school. Whilst nothing has been set in stone as of yet, they are pretty sure that they want to get into the construction industry, specifically, building high-tech 'smart barns'.

Their first design (shown below) has a series of 'smart sensors' placed at various locations around the barn floor. Each of these sensors is connected to the network via ethernet cables. In the diagram below, sensors are represented by nodes and ethernet cables are represented by the edges connecting them. The weights on the edges indicate the total length, in metres, of ethernet cable required for that section.



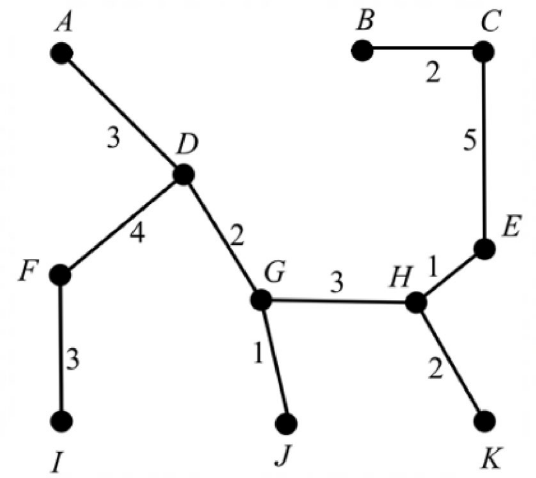
Jordan thinks that they are using too much ethernet cable and wants to remove some of the connections from the design.

a. Using Prim's algorithm, find the minimal spanning tree for the weighted graph shown above starting from *A*. Show the order of the edges added to the tree. 2 marks

Marks	**0**	**1**	**2**	**Average**
%	13	69	19	**1.06**

Assessors Comments: *Many students did not describe the edges being added and instead only listed nodes. Students are encouraged to pay attention to the specific instructions given in the question.*

Below is an example of a high scoring response to this question:



Correct MST	A1
Correct order of edges: AD, DG, GJ, GH, HE, HK, DF, FI, EC, BC	A2

SECTION B - continued

Sukhman is not convinced and argues that the minimal spanning tree network proposed by Jordan would produce too much lag (in reality the lag would actually be caused by Sukhman listening to too much Donda).

If the lag experienced between two sensors is directly proportional to the length of ethernet cable the signal has to traverse between the two sensors then:

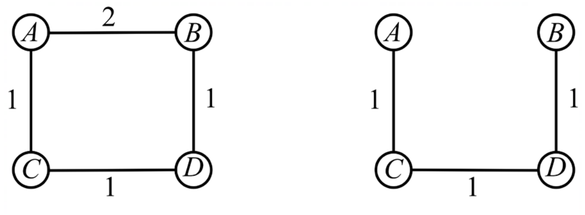
b. Explain, with use of an example, how the minimal spanning tree does not necessarily produce the shortest path distance between two pairs of nodes. 2 marks

Marks	**0**	**1**	**2**	**Average**
%	0	38	63	**1.63**

Assessors Comments: *Many students neglected to provide an example to accompany their description despite the question explicitly asking for one.*

Below is an example of a high scoring response to this question:

The MST produced the lowest cost to connect all nodes to the tree. It does not consider what is the shortest path between any two nodes. Consider the following example where we have 4 nodes, A, B, C and D. The distance from A to B is 2 units but all other edges are 1 unit in length. The MST created will result in the distance from A to B being 3 units in total but the minimum distance connecting the two is actually 2 units.



Original Graph MST

An explanation of how the MST does not create the shortest path between two nodes is given.	A1
An example showing that the minimum path distance between two nodes is not given by the MST.	A2

Not willing to let Sukhman discredit him so easily, Jordan wants to determine exactly what the expected lag time is between each pair of nodes in the original design. He is choosing between using Dijkstra's algorithm, the Bellman-Ford algorithm or the Floyd-Warshall algorithm.

c. For each of the named algorithms above, compare their suitability for finding the solution to the given problem and state which algorithm Jordan should use providing a justification of why it is the most suitable. 4 marks

Marks	0	1	2	3	4	Average
%	13	38	19	25	6	**1.75**

Assessors Comments: *This question was poorly answered and it was apparent that many students are still unfamiliar with the problems solved by each of the named algorithms. Each of these algorithms could have been used to solve the given problem and students are encouraged to review the example answer below to see what was expected of them when discussing the suitability of each algorithm.*

Below is an example of a high scoring response to this question:

Dijkstra's could be used as there are no negative edge weights and so it will return the shortest distance between a pair of nodes. By repeatedly running Dijkstra's between each pair of nodes in the graph, it will generate the answer.

Bellman-Ford is also suitable as it can be used to find the shortest distance between a start node and all other nodes in the graph. Thus, by calling it repeatedly with each node as the start node, it can be used to generate the correct answer.

Floyd-Warshall is suitable as it does return the shortest distance between all pairs of nodes.

Floyd-Warshall should be chosen as it will have the lowest time complexity ($O(V^3)$ vs $O(V^3 log(V))$ for Dijkstra and $O(V^2E)$ for Bellman-Ford).

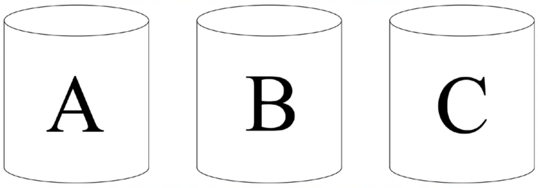
**note that V^2E is generally greater than V^3 for a complete graph so in its worst case Bellman-Ford will be worse than Floyd-Warshall despite having the same worst case asymptotic time complexity.*

Explanation of Dijkstra's appropriateness including mention of no negative edge weights and needing to be repeatedly called.	A1
Explanation of Bellman-Ford needing to be repeatedly called.	A2
Explanation of Floyd-Warshall being appropriate.	A3
Selection of Floyd-Warshall including justification based on time complexity.	A4

Amish recently approached Sukhman to see if he could join in with Sukhman's and Jordan's Barn Building enterprise as he loves building barns (he is Amish after all). When he asked about it, Sukhman told him that they weren't currently looking for investors. Amish felt this was just rude and is now seriously considering becoming mortal enemies with Sukhman.

Question 4 (7 marks)

To entertain her friends Samantha has come up with a new game. It consists of three empty cans of Sustagen that have been provided to her by Mr Kermond. She labels the outside of each can with either an A, B or C.

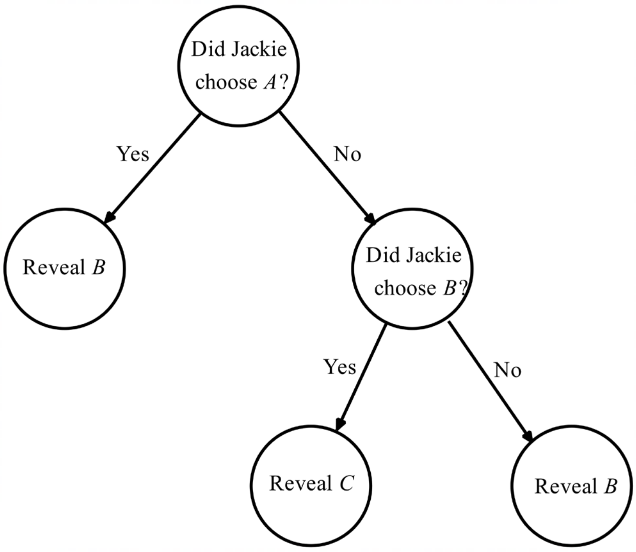


Inside one of the cans Samantha puts a Mars bar, while she leaves the other two cans empty. She then asks Jackie to pick which can they think the Mars bar is in. Samantha knows where the Mars bar is so she then chooses one of the cans which is empty and was not picked by Jackie, and shows Jackie it is empty. Jackie can then decide whether or not to change their choice can they think the Mars bar is in.

a. Assuming that Samantha has put the Mars bas in the can labelled A, draw a decision tree to help Samantha work our which empty can she should choose to show Jackie. 3 marks

Marks	0	1	2	3	Average
%	0	31	31	38	**2.06**

Below is an example of a high scoring response to this question:



An attempt to draw some sort of tree is evident	A1
Decision tree is provided but is not fully correct or does not provide a correct output	A2
Decision tree provided is accurate and returns the correct output	A3

Samantha's game becomes a huge hit with Jackie and he now wants to play it all the time! Samantha would rather be spending time studying for the Algorithmics exam though so she decides to try and write an algorithm that will automatically choose which can should be revealed to Jackie each time.

b. Write pseudocode that takes as input the can with the Mars Bar in it and the can that Jackie chooses and outputs the can that Samantha should choose to show Jackie. 4 marks

Marks	0	1	2	3	4	Average
%	6	13	31	25	25	**2.50**

Below is an example of a high scoring response to this question:

//Input: Letter representing the location of the mars bar and a letter representing the choice of can by Jackie.

```
Algorithm canRevealer(x,y)
Input: a letter representing the location of the mars bar,
x, and a letter representing the can chosen by Jackie, y.

    List = ['A', 'B', 'C']
    if x = y
        for i in range length of List[]
            if List[i] = x
                continue
            else
                return List[i]
    else
        for i in range length of List[]
            if List[i] != x and List[i] != y
                return List[i]
            else
                continue
```

A comparison of Jackie's can choice and the can with the Mars bar is evident.	A1
An attempt to deal with the case where Jackie selects the can with the mars bar in it is evident.	A2
An attempt to deal with the case where Jackie selects a can that doesn't have a mars bar in it is evident.	A3
Pseudocode returns a correct can for reveal to Jackie (that does not contain the mars bar).	A4

Question 5 (4 marks)

Use induction to prove that $n! > 2^n$, for $n \geq 4$.

Marks	0	1	2	3	4	Average
%	13	31	13	19	25	2.13

Below is an example of a high scoring response to this question:

Base Case: If n=4, n!=4x3x2x1=24 and $2^4 = 16$.
As 24>16, the statement that $n! > 2^n$ is true for the base case

Induction hypothesis: Assume that for some integer, k>4, that it is true that $k!>2^k$.

Induction step: Investigate the k+1th case

LHS	RHS
(k+1)!=(k+1) x k!	$2^{k+1}=2 \times 2^k$

as k > 4, then k+1 > 2
therefore, as $k! > 2^k$, (k+1)k! must be greater than 2×2^k

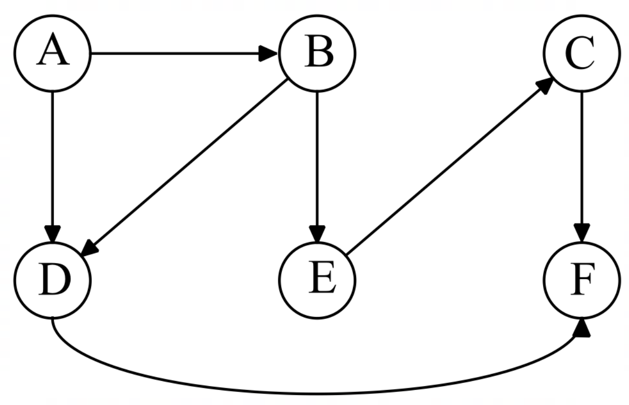
Final conclusion: As we know that the statement that $n! > 2^n$, for $n \geq 4$ is true in the base case and we have shown, by induction, that if it is true for a value k then it is true for the k+1th case, we can say that it is true for all $n \geq 4$.

Identification of base case	A1
Induction hypothesis	A2
Inductive step	A3
Final conclusion	A4

Question 6 (2 marks)

Ainsley is looking for the next lettered mug to bring to his online Maths Methods class. For some reason, the mugs have been hidden in a labyrinth where each mug has been placed in its own room and each room can only be accessed through the doorways connecting them

The diagram below shows a portion of the labyrinth where each room is represented by a node, the label on the node represents the letter on the lettered mug and the directed edges indicate which room can be travelled to from which other room.



Assume that Ainsley starts at Node A and always chooses to travel to rooms in alphabetical order when presented with a choice between rooms.

a. Write the order in which Ainsley will visit the nodes in the labyrinth if he uses a depth first search to look for the next mug. 1 mark

Marks	0	1	Average
%	44	56	**0.56**

A, B, D, F, E, C	A1

b. Write the order in which Ainsley will visit the nodes in the labyrinth if he uses a breadth first search to look for the next mug. 1 mark

Marks	0	1	Average
%	13	88	**0.88**

A, B, D, E, F, C	A1

Question 7 (7 marks)

Ivan and Darren have become obsessed with a new AR game that is soaking up time that they would otherwise be spending on Algorithmics. They know that there is a portal for the game located somewhere on the ground floor of the school. In order to find the portal they have represented the ground floor as a 10x20 grid of squares. Their plan is to visit each square in the grid one-by-one, search that square for the portal using the AR game on their phones, and stop when they have found the portal.

a. Assume every square has a coordinate (x, y), where $1 \leq x \leq 10$, $1 \leq y \leq 20$, and Darren and Ivan after searching one square will go to a neighbouring square. Write some pseudocode that prints out the coordinates of the squares in the order Ivan and Darren should visit them.

3 marks

Marks	0	1	2	3	Average
%	38	6	31	25	**1.44**

Below is an example of a high scoring response to this question:

```
Algorithm Traversal(A[])
Input: An array A[] with dimensions x by y

     For i= 1 to i = x
          For j = 1 to j = y
               If x is odd
                    Print(i,j)
               if x is even
                    Print(i,y-j+1)
```

Nested x and y values are evident	A1
Coordinates are printed out	A2
The order of in which coordinates are printed is a valid order.	A3

Prabhu notices what Ivan and Darren are doing and suggests that they represent the problem as a graph instead where nodes represent each square to be searched and adjacent squares have edges connecting them. Prabhu argues that this way they can use a Depth First Search to try and find the portal and thus be 'studying' Algorithmics at the same time as playing the game.

Prabhu supplies Ivan and Darren with the following pseudocode for a Depth First Search.

```
DFS(G, x, target)
Visited(x) = True
If x = target
     Return x
Else
     For each neighbour, n, of x.
          If visted(n) = False
               Return DFS(G,n)
```

b. State and give reasons for what would be the worst-case asymptotic time complexity for Prabhu's algorithm. 2 marks

Marks	0	1	2	Average
%	19	19	63	**1.44**

Below is an example of a high scoring response to this question:

In the worst case, Prabhu's algorithm will have a time complexity of O(n) as it will have to check every node in the graph.

O(n)	A1
Explanation	A2

c. State and give reasons for what would be the best-case asymptotic time complexity for Prabhu's algorithm. 2 marks

Marks	0	1	2	Average
%	6	13	81	**1.75**

Below is an example of a high scoring response to this question:

In the best case, Prabhu's algorithm will have a time complexity of O(1) as it will find the target node as the first node that is visited.

O(1)	A1
Explanation	

Question 8 (3 marks)

In her spare time Julee has developed a new way to mix up lists. In order to explain her method to Yasmin, Julee has written the following pseudocode.

```
//Input: A list L with n items
//Output: A new, mixed up List L, with n items

Algorithm mix(L,n)
    If n > 1
       Let a = the list consisting of every second item
               starting with the first item.
       Let b = the list of items in L that are not in a.

       Let a = mix(a,n/2)
       Let b = mix(b,n/2)

       Let L = the list a joined to the end of the list b.
    return L
```

Having shared her pseudocode with Yasmin, Julee then asks Yasmin to find out the time complexity of her algorithm for her since she is busy studying for her exams and can't be bothered doing it herself. Yasmin, surprisingly, agrees to help her out.

Assume that the number of operations to construct a is n/2 and b is n/2, where n is the number of items in L, and there is one more operation required to join a to the end of b.

a. Write a recurrence relation for the number of operations **mix**() will perform. 2 marks

Marks	0	1	2	Average
%	50	44	6	**0.56**

Assessors Comments: *Many students could not correctly identify the linear function that would run in addition to the recursive call. It was also surprising how many students forgot to include the base case in their answer.*

Base Case: $T(1) = 0$	A1
$T(n) = 2T\left(\frac{n}{2}\right) + n + 1$	A2

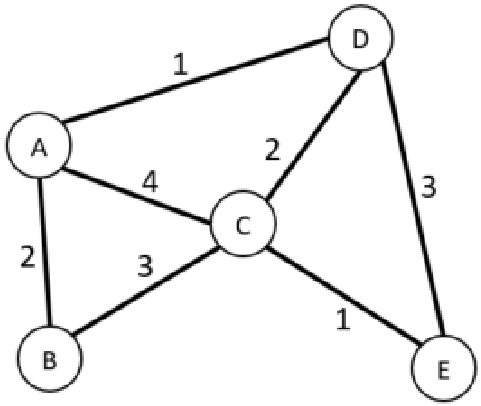
b. What is the Big-O solution to the recurrence relation found in part **a.**? 1 mark

Marks	0	1	Average
%	31	69	**0.69**

$O(n\log(n))$	A1

Question 9 (5 marks)

Consider the following graph that Andrew Nie drew one day whilst he was philosophically pondering the meaning behind the existence of the Durian.



a. Identify two features of the above graph. 2 marks

Marks	0	1	2	Average
%	0	0	100	**2**

Accepted answers were:
- Labelled
- Weighted
- Connected
- Cyclic
- Undirected

1 correctly identified feature	A1
2 correctly identified features of the graph	A2

b. Describe what an Eulerian Circuit is and explain why the above graph does not contain one. 2 marks

Marks	0	1	2	Average
%	13	31	56	**1.44**

Below is an example of a high scoring response to this question:

An Eulerian Circuit is a path that traverses each edge in the graph exactly once and that returns to its starting position at the end. In order for an Eulerian Circuit to exist in a graph, there must be no odd degree nodes in the graph at all. As can be seen, nodes A and D both have an odd degree therefore meaning an Eulerian Circuit through this graph is not possible.

Correct description of an Eulerian Circuit	A1
Description of why it cannot exist for this given graph	A2

c. Find the width of the above graph. 1 mark

Marks	0	1	Average
%	25	75	**0.75**

4	A1

Question 10 (7 marks)

Ruby has been thinking a lot about the following version of the Travelling Salesman problem during the school holidays:

"Given a set of n cities each connected by to one another by paths of set lengths, find the shortest path that will allow a travelling salesman to visit each city exactly once and return to the starting city."

She has a dream one night where she is able to find the optimal solution to this problem using Prim's Algorithm. When Ruby wakes up, she wonders whether Prim's algorithm could actually be used to find a solution in polynomial time.

a. Explain what the significance of Ruby finding a way to solve the given version of the Travelling Salesman problem in Polynomial time would be to the P vs NP question would be. 3 marks

Marks	0	1	2	3	Average
%	19	0	38	44	**2.06**

Below is an example of a high scoring response to this question:

The TSP described is an example of an NP-Hard problem. It is possible to transform all NP and NP-Complete problems into a version of the NP-Hard TSP in polynomial time meaning that if a solution to the TSP is found in polynomial time, then all of NP and NP-Complete will collapse to P. Other NP-Hard problems (with the exception of the TSP Ruby has solved) will remain in NP-Hard.

Recognition of TSP being NP-Hard	A1
Relationship between NP and NP-Hard is explained	A2
Description of NP and NP-Complete collapsing to P with Ruby's discovery	A3

Jeremy hears about Ruby's idea and thinks that it is unlikely that Prim's could be used to solve the Travelling Salesman Problem in polynomial time. He instead thinks that the use of a Randomised Heuristic would be more appropriate.

b. Explain how a Randomised Heuristic could be used to help find a solution to the Travelling Salesman problem and discuss the quality of this given solution compared with a brute force approach. 4 marks

Marks	**0**	**1**	**2**	**3**	**4**	**Average**
%	6	6	19	44	25	**2.75**

Below is an example of a high scoring response to this question:

A brute force approach is guaranteed to produce the optimal solution to the TSP but will take a very long time to produce said solution. Use of randomised heuristics allow for solutions to be generated more quickly but these solutions cannot be verified as being optimal solutions and so are considered as 'good enough' solutions or local minimum.

An example of a randomised heuristic that could be used to solve the TSP would be to generate a starting solution to the TSP and then randomly select two edges and swap their end points to see if that results in a reduction in the overall distance of the solution. If it is, keep the answer and continue swapping other edges until you reach a certain distance that you are happy with or a certain number of swaps have occurred. If the solution is not better, revert back to the old solution and try a different combination of edges to swap.

Valid randomisation approach is explained	A1
Explanation that the solution provided by radomised heuristics cannot be verified to be the optimal solution	A2
Explanation that brute-force approach will generate the optimal solution	A3
Description of brute-force not being tractable for large inputs	A4

Question 11 (4 marks)

Let G be a connected graph with n vertices and n-1 edges. Prove that G must have a vertex of degree 1.

Marks	**0**	**1**	**2**	**3**	**4**	**Average**
%	38	13	13	6	31	**1.81**

Assessors Comments: *Many students attempted, without success, to use a proof by induction for this question. Often, in such approaches, the induction hypothesis was incorrectly stated and the induction step was not clearly executed.*

Below is an example of a high scoring response to this question:

Assume that there are no nodes of degree one in G.
This means that every node must have a degree ≥ 2 as there cannot be a node of degree 0 as this would mean the graph is not connected.
If this is the case then the total number of edges in G must be ≥ n (as if we add the degree of each node and divide by 2 as each edge is shared, then because the degree of each node is ≥ 2, the number of edges will be ≥ n.)
But this is a contradiction as we are told that there are only n-1 edges in the graph. So our assumption must have been incorrect and there must be at least one vertex of degree one.

Proof by contradiction:

Correct assumption stated	A1
Reference to connectedness	A2
Contradiction shown	A3
Summarizing statement	A4

Question 12 (5 marks)

Dechlan and Michael have successfully reached the highest of heights, playing against one another in the grand final of the inaugural JMSS Connect-4 competition.

Connect-4 is a solved game, which means that an outcome can be predicted from any state of the game with the assumption that both players play perfectly.

In this game, each player takes turns in placing one of their counters into one of seven vertical column of their choosing. The counter, when put into a column will occupy the space that is the lowest unoccupied state in this column unless the column is already full (a column can hold at most six counters). If they can achieve getting 4 of their counters lined up in a row either vertically, horizontally or along the diagonal without any opponent counters in the way, they will be declared the winner.

Dechlan wishes to use the Minimax algorithm to assist him in playing the game.

In the space below, describe the way in which Minimax could be used to assist Dechlan in choosing what moves he should make. As part of your answer discuss the feasibility of using an approach like this from the very beginning of the game and what assumptions the algorithm will make.

Marks	**0**	**1**	**2**	**3**	**4**	**5**	**Average**
%	38	6	6	31	19	25	**3.13**

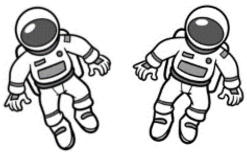
Below is an example of a high scoring response to this question:

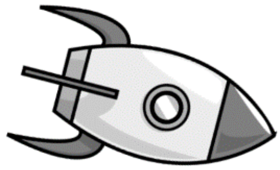
Minimax works by generating all possible game states from the current position to an end state. It assigns a value to each end state where larger scores indicate player one winning and lower scores indicate player two winning. It then makes the assumption that both players are using minimax and will make a move that is most beneficial to them at each move. Using this assumption, it propagates the scores back up the tree maximising for player one's turns and minimising for player two's turns until it reaches the current move where it will offer the most advantageous move for the current player.

Due to the large number of game states that are possible in even the simplest games, it is not tractable for Dechlan to use Minimax from the beginning of the game unless he can limit the number of turns that the algorithm will generate and base the next move off this truncated version of the game state tree.

Generation of game states	A1
Assigning of values	A2
Propagation of scores upwards	A3
Assumption of both players using minimax	A4
Statement that the use of Minimax will not be feasible from the beginning of the game.	A5

Question 13 (8 marks)





Somewhere deep in space, Aabshaar, Ben, Charlie and Dasindu are astronauts returning from a secret space mission. Unluckily for them, the computer AI that controls their spaceship has gone crazy and is refusing to open the pod-bay doors between the spaceship it controls and the pod containing the astronauts. Since they cannot dock the pod with the spaceship, the astronauts will be forced to take a difficult spacewalk between the pod and the emergency airlock on the spaceship. Fortunately each astronaut has their own space-suit.

Unfortunately they only have one portable oxygen-pack between them, which the suits require to work. This pack can be used simultaneously (if necessary) by two astronauts travelling together, but it cannot provide oxygen for three or more at the same time.

Since there is only one pack it will have to be taken back and forth until all the astronauts are safely onboard. It is a difficult space walk and abilities of the astronauts vary, so their times to travel between the pod and the space station also vary. Two astronauts travelling together move at the speed of the slowest astronaut, since they are kept together by the oxygen-pack.

For example, suppose Aabshaar (A) takes 1 minute, Ben (B) takes 2 minutes, Charlie (C) takes 4 minutes and Dasindu (D) takes 5 minutes. The following combination of walks gets the astronauts onto the space station in 13 minutes. A and D travel to the station (5 minutes), A travels back to the pod (1 minute), A and C travel to the station (4 minutes), A travels back to the pod (1 minute) and finally A and B travel to the station (2 minutes). Note that this is not the optimal solution.

a. One approach to finding a combination of walks that will get Aabshaar, Ben, Charlie and Dasindu into the spaceship as quickly as possible is to use a greedy algorithm.

Explain whether or not this is a feasible approach. Include a discussion of the optimality of the resultant solution as part of your answer. 2 marks

Marks	**0**	**1**	**2**	**Average**
%	19	6	75	**1.56**

Not feasible	A1
A greedy approach will return a sub-optimal solution	A2

Unfortunately, Aabshaar, Ben, Charlie and Dasindu have no idea how to write a greedy algorithm let alone solve the given problem and so they ask a passing alien (named Sharan) for some help. Sharan is a brutish sort of alien and only like brute-force approaches though.

b. Write pseudocode for a brute force approach to finding the minimum possible time required get Aabshaar, Ben, Charlie and Dasindu into the spaceship. 4 marks

Marks	**0**	**1**	**2**	**3**	**4**	**Average**
%	63	13	6	19	0	**0.81**

Assessors Comments: *Many students struggled with this question and are encouraged to look at the provided example solution. Many students got caught out trying to write down a way of generating all paths. This was not necessary, however, and students are encouraged to reflect upon the level of detail they are required provide when writing pseudocode for such a complex problem.*

Below is an example of a high scoring response to this question:

```
Algorithm()
    MinTime = ∞

    Let walks = the list of all of the possible walks, where
    a walk is also a list where the first, third and fifth
    item are pairs of characters from the set {A,B,C,D} and
    the second and fourth item are one of the characters
    {A,B,C,D}

    For each walk in walks
        If valid(walk)
            Let time = compute_time(walk)
            If time < MinTime
                MinTime = time
    Return MinTime
```

Attempt to generate/use all the combinations of walks	A1
Total cost of each path is calculated	A2
The minimum cost path is kept track of	A3
The algorithm outputs the correct minimum cost path	A4

Sharan, after helping the astronauts successfully get into their spaceship, becomes very interested in the troublesome computer's Artificial Intelligence (AI) system. He and Aabshaar enter into a philosophical discussion about whether this AI system is an example of strong or weak AI.

c. In the space below, describe what John Searle's Chinese Room Argument would suggest about the nature of the spaceship's AI. 2 marks

Marks	**0**	**1**	**2**	**Average**
%	13	38	50	**1.38**

Assessors Comments: *Many answers to this question did not contain a complete response. It is important to mention Searle's concept of a computer being incapable of understanding and thus being a form of weak AI when discussing the proposed outcomes of Searle's Chinese Room Argument.*

Below is an example of a high scoring response to this question:

John Searle's Chinese Room Argument suggests that computers are incapable of understanding what they are doing and can only simulate intelligence. Thus he would argue that the spaceships AI is an example of weak AI.

The Chinese Room argument suggests that all computer AI is only capable of simulating intelligence – Weak AI	A1
It suggests that the spaceship's AI is not capable of understanding what it is doing	A2

Question 14 (5 marks)

Kody and Shiann have broken into the JMSS labs in the hope of being able to steal some gel electrophoresis kits. They want to try and use DNA computing to crack Mr Chisholm's password so that they can then edit their chronicle entries in Compass.

Matthew questions how this alternative method of computation could possibly help them overcome the current limits of computability relating to encryption.

a. Describe what is meant by the phrase 'current limit of computability'. 2 marks

Marks	0	1	2	Average
%	13	31	56	**1.44**

Below is an example of a high scoring response to this question:

There are some problems that are so inherently hard to solve that even though we may have an algorithm that can theoretically solve them, the length of time or amount of space required to find said solution can be exceptionally large so as to be impractical.

Mention of time limitations	A1
Mention of space limitations	A2

b. Describe **one** way DNA computing could be used to overcome current limits of computation. 3 marks

Marks	0	1	2	3	Average
%	19	19	31	31	**1.75**

Below is an example of a high scoring response to this question:

DNA computing involves storing information as strands of DNA and using biological processes to manipulate the strands towards finding a solution. Due to the large amount of DNA that can be included in a small space, DNA computing allows us to generate a solution through mass parallel processing. This mass parallel processing requires smaller space than conventional computing processors and means that the solution can be generated in less time.

Relating of answer to either time or space complexities	A1
Student has made some realistic attempt to describe how DNA computing can overcome current limits of computing.	A2
Student provides a thorough description of how DNA computing can overcome current limits of computing.	A3

Unfortunately for Kody and Shiann, they try to use some of Will's DNA and, like Will, it refuses to output anything meaningful. Marcus, who has been watching what is going on carefully just shakes his head in disappointment. Mr Chisholm's password isn't particularly secure. His love for the Melbourne Demons is well documented and from there, realising that his password is simply "GoD33s!" isn't particularly challenging.

After sufficient head shaking, Marcus logs back into Compass and adds some additional negative chronicle entries to Kody and Shiann's portfolios. "That'll keep them busy" he thinks to himself.

Question 15 (5 marks)

Robert and Joshua J are having a discussion with Vincent, Rish and Jessie about the idea of Hilbert's Program when all of a sudden, Finn and Joshua L arrive and are curious about what Hilbert's Program was.

a. In the space below, describe the main goals of Hilbert's Program. 3 marks

Marks	**0**	**1**	**2**	**3**	**Average**
%	63	0	13	25	**1.00**

Assessors Comments: *Many answers to this question stated Consistency, Completeness and Decidability but did not define them.*

Below is an example of a high scoring response to this question:

Hilbert's Program was an attempt to find a set of axioms from which it would be possible to formalise all of mathematical theory. This program would be complete, meaning that every true statement would be able to be proven true, consistent, meaning that there would be no contradictions that would arise from the logical statements produced, and decidable, meaning that it would always be possible to determine if a statement was able to be proven or not.

Description of completeness	A1
Description of consistency	A2
Description of decideability	A3

END OF QUESTION AND ANSWER BOOK

Paul and Ranudi arrive and, hearing about what Hilbert's Program is, think that it sounds like a great idea. Kaelen, however, points out that because of Turing's demonstration of the Halting Problem, Hilbert's Program will never be possible.

b. Describe the outcome of Turing's proof of the Halting Problem and its subsequent implications for Hilbert's Program. 3 marks

Marks	0	1	2	3	Average
%	19	19	38	25	**1.69**

Below is an example of a high scoring response to this question:

The result of Turing's proof of the Halting Problem was that he had shown that there are some problems that are undecidable meaning that Hilbert's Program, which required mathematics to be decidable, was not possible.

The Halting Problem demonstrated undecidability	A1
Hilbert's Program required mathematics to be decidable	A2
Therefore Hilbert's Program was not possible	A3

Vedansh, Nathan, Andrew L, Li Yue, Aden, Nikolai and Karsh all arrive to the discussion and the party really gets started.

Nearby, Wei sees the large gathering and is disappointed that he wasn't invited. After all, he has an excellent understanding of the Universality of Computation and could have answered the groups questions with ease. In retribution for being left out, Wei calls the police and Vedansh, Nathan, Andrew L, Li Yue, Aden, Nikolai, Karsh, Paul, Ranudi, Kaelen, Robert, Joshua J and Joshua L, Vincent, Rish and Jessie are all fined for not adhering to lockdown restrictions.

Somehow Finn avoids getting fined. Noone knows why this is the case but Vedansh theorises that it has something to do with his name being only one vowel short of a Fine.