JOHN MONASH SCIENCE SCHOOL

VICTORIAN CERTIFICATE OF EDUCATION

2015

STUDENT NAME:

ALGORITHMICS (HESS)

Practice Exam 1

SOLUTIONS

QUESTION AND ANSWER BOOK

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	10	10	80
		Total	100

- Students are permitted to bring into the test room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination: blank sheets of paper and/or correction fluid/tape.

Materials supplied
- Question and answer book of 24 pages.
- Answer sheet for multiple-choice questions.

Instructions
- Write your name in the space provided above on this page.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the test room.

SECTION A – Multiple-choice Questions

Question #	Answer
1	D
2	C
3	A
4	A
5	C
6	B
7	C
8	D
9	A
10	A
11	D
12	B
13	B
14	A
15	A
16	C
17	A
18	C
19	D
20	B

END OF SECTION A
TURN OVER

SECTION B

Instructions for Section B
Answer **all** questions in the spaces provided

Question 1 (12 marks)

Pavel has been relaxing over the September holidays by carrying out some casual testing of various algorithms that he is suspicious of being a bit dodgy. He is considering the differences between black box and white box testing techniques.

a. Describe the key differences between black box and white box testing of algorithms. 2 marks

Black Box Testing is where you are only testing that the algorithm or program provides correct outputs for given inputs. You don't need to know anything about the internal workings of the algorithm.	A1
White Box Testing requires the ability to read and interpret the code and involves checking the code line by line to identify errors or inaccurate/inefficient operations.	A2

Pavel decides to do some black box testing first. He knows that the algorithm under investigation has three input variables, *A, B* and *C*, and that these variables can take the following values:

A = {True, False}
B = {1, 2, 3}
C = {0, 1}

b. **i.** What is the total number of test cases Pavel is required to test if he wishes to test every possible combination of input values? 1 mark

12	A1

ii. What is the total number of test cases Pavel is required to test if he uses pair-wise testing? 1 mark

6	A1

iii. Describe the reasoning and justification for using pair-wise testing to test the algorithm? 2 marks

We assume that the majority of errors that will occur will occur when we test individual or combinations of 2 inputs.	A1
By testing all pairs of inputs, we reduce the total number of tests that we need to do and have a pretty good chance of checking for the most common sorts of errors.	A2

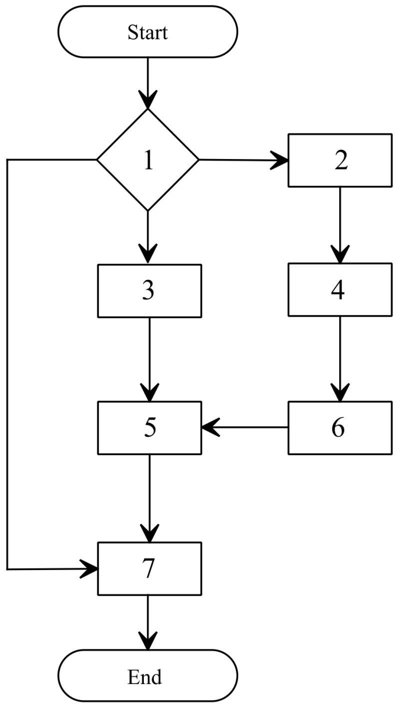
iv. List a possible combination of pair-wise test cases that Pavel could use to test this algorithm's inputs. 2 marks

1	T	0
1	F	1
2	T	1
2	F	0
3	T	0
3	F	1

Deduct ½ a mark for every mistake to a maxium of 2 marks and then round down.

A1 & A2

Pavel decides to do some white box testing next. He constructs the following flow diagram to represent the possible pathways that the algorithm can take.



c. **i.** What is the path coverage of this graph? State all possible paths as part of our solution. 2 marks

3 paths	A1
1 → 3 → 5 → 7 1 → 7 1 → 2 → 4 → 6 → 5 → 7	A2

ii. How many paths need to be covered in order to ensure branch coverage of this graph? State these paths as part of your solution. 2 marks

3 paths	A1
1 → 3 → 5 → 7 1 → 7 1 → 2 → 4 → 6 → 5 → 7	A2

Question 2 (3 marks)

Michaela is searching for the answers to life, the universe and everything. She comes across the following search algorithm and wants to know if it is going to be of use to her when looking for the number 42 in the list of values;{1, 13, 7, 42, 666, 23, 5, 50}.

LinearSearch (*A*[*0..n-1*], *x***)**

//**Input:** an array of values, *A*[*0..n-1*] and a value to search for, *x.*
//**Output:** an integer value corresponding to the location of *x* in the array A[*0..n-1*]

```
if list is empty
   return "value not found"
i ← 0
while i < n
   if A[i] = x
      return i
   else
      i = i +1
return "value not found"
```

a. i. What is the best case time-complexity of this algorithm? 1 mark

O(1)	A1

ii. What is the worst case time-complexity of this algorithm? 1 mark

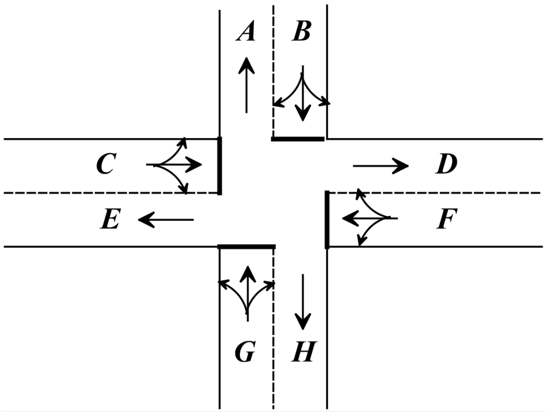
O(n)	A1

Jun suggests to Michaela that she should use Binary Search instead of Linear Search to help her find the number 42.

b. Give one reason why Binary Search would not be a suitable algorithm to use with the given list of values? 1 mark

Binary Search requires that the list be sorted into either ascending or descending order. This is not the case for this list.	A1

Question 3 (9 marks)
Alan is considering a career as a road designer. Near his house is an intersection like the one shown below.



Cars can enter this intersection through points *B, C, F* or *G.*
It is then possible to move through the intersection as follows:

From point *B* it is possible to move to point *E, D* or *H.*
From point *C* it is possible to move to point *A, D* or *H.*
From point *F* it is possible to move to point *A, E* or *H,*
From point *G* it is possible to move to point *A, E* or *D,*

Alan wants to model the intersection so that he can then determine what the optimum sequence of lights will be that will allow cars to be able to access each pathway through the intersection equally but without the risk of any accidents (paths that intersect).

a. In the space below, draw a graph that could model this intersection and the possible. Be sure to label nodes and any other important features of the graph appropriately. 2 marks

Accurate graph representation of intersection with labels	A1 & A2

b. Describe two properties of your graph from part **a.** and justify the use of both of these properties with respect to the original problem. 4 marks

Property 1

Identification of a feature of the graph	A1
Appropriate justification of it's use in this model	A2

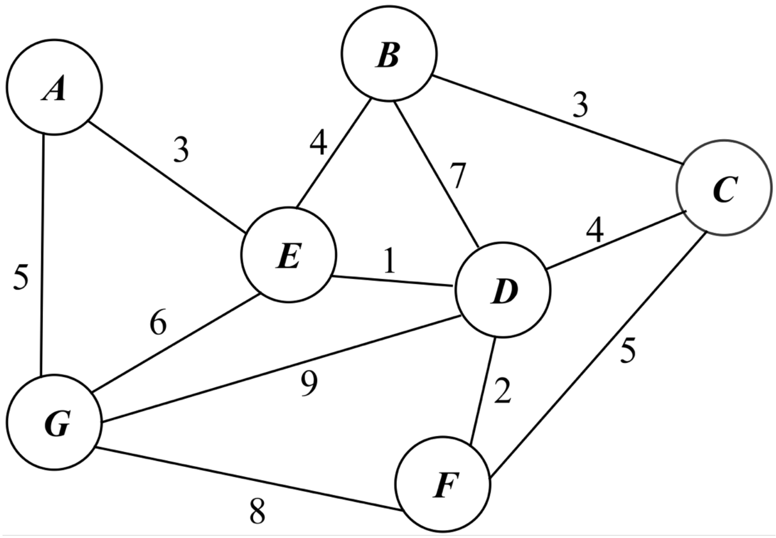
Property 2

Identification of a feature of the graph	A3
Appropriate justification of it's use in this model	A4

c. Explain how you would go about determining the best combinations or sequences of pathways through the intersection. Note that you do not have to actually find this solution. 3 marks

The problem can be solved by converting it to a form of the graph colouring problem	A1
Nodes would represent the various pathways through the intersection and pathways that cannot occur simultaneously are connected by edges.	A2
By colouring the graph with the minimal amount of colours so that no two connected nodes are the same colour, we can identify which pathways can occur simultaneously in passing through the intersection.	A3

Question 4 (14 marks)
Ryan and Oliver are planning on visiting their friends during the holidays but don't want to waste their time travelling between houses. The graph below represents the roads (edges) connecting each of their friends houses (nodes) and the edge weightings represent the distances, in kilometres, of each road section.



Ryan and Oliver are initially at node *A*.

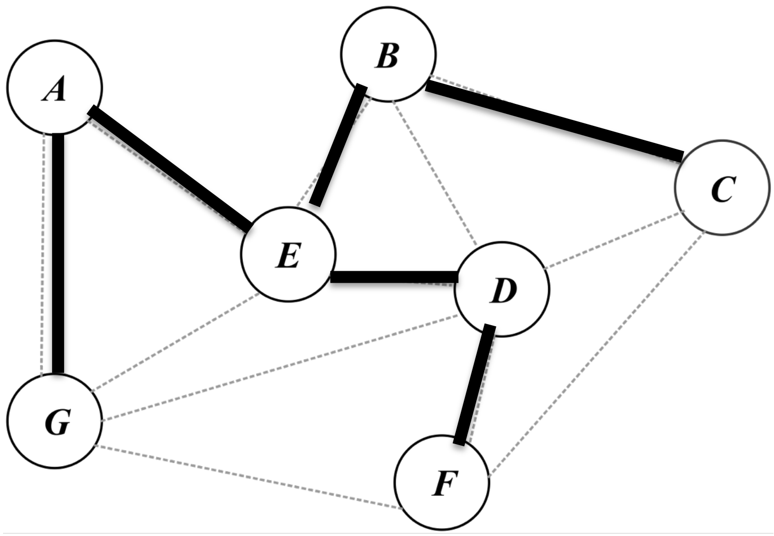
a. Oliver initially wants to use the Bellman-Ford algorithm to work out the minimum spanning tree of this network but Ryan suggests that Prim's algorithm would be more appropriate and quicker. In the space below, explain who is correct and justify your answer with an explanation. 3 marks

Ryan is correct	A1
Bellman Ford finds the shortest path between pairs of nodes and doesn't give the minimal spanning tree	A2
Prim's Algorithm does find the minimal spanning tree.	A3

Ryan is taller than Oliver so he wins the argument regardless of whether he is correct or not

b. In the space below, use Prim's Algorithm to find the minimal spanning tree. Record the order in which you add edges in the table provided and then draw this minimal spanning tree on the graph provided. 3 marks

1st	2nd	3rd	4th	5th	6th
A-E	E-D	D-F	E-B or D-C	B-C	A-G



Deduct 1 mark for every mistake or error to a maximum of 3 marks	A1, A2 & A3

Victor notices Ryan and Oliver planning their visits and points out that the minimal spanning tree is not necessarily going to give them a path that they can follow through each of the nodes. Victor informs them that the problem they are trying to solve is actually an example of the Travelling Salesman Problem.

c. In the space below, describe the Travelling Salesman Problem and explain what is meant when it is described as being an NP-Hard problem. 3 marks

Travelling Salesman is the problem of finding the pathway that a salesman should take to visit every node in a graph exactly once and return to the beginning node in the shortest time or distance.	A1
This problem is NP Hard because it quickly becomes intractable as the number of nodes grows larger	A2
Meaning that it is not possible to find a solution in polynomial time nor verify its solution in polynomial time	A3

Yin-Lee overhears Victor, Ryan and Oliver discussing the Travelling Salesman Problem and gets excited. She has access to all of the equipment needed to do DNA Computing and was looking for an excuse to use it.

d. **i.** In the space below, explain the differences and similarities between DNA Computing and electronic forms of computing. 2 marks

DNA Computing and electronic forms of computing can both be reduced to Turing Machines and so anything that can be computed by DNA Computing can also be computed by electronic forms of computing	A1
Differences are that DNA computing utilises biological process and DNA molecules to achieve massive parallel processing whereas electronic forms of computing utilise logic gates and electronic circuits.	A2

ii. Explain how DNA Computing can be used to find a solution to NP-Hard problems such as the Travelling Salesman Problem 3 marks

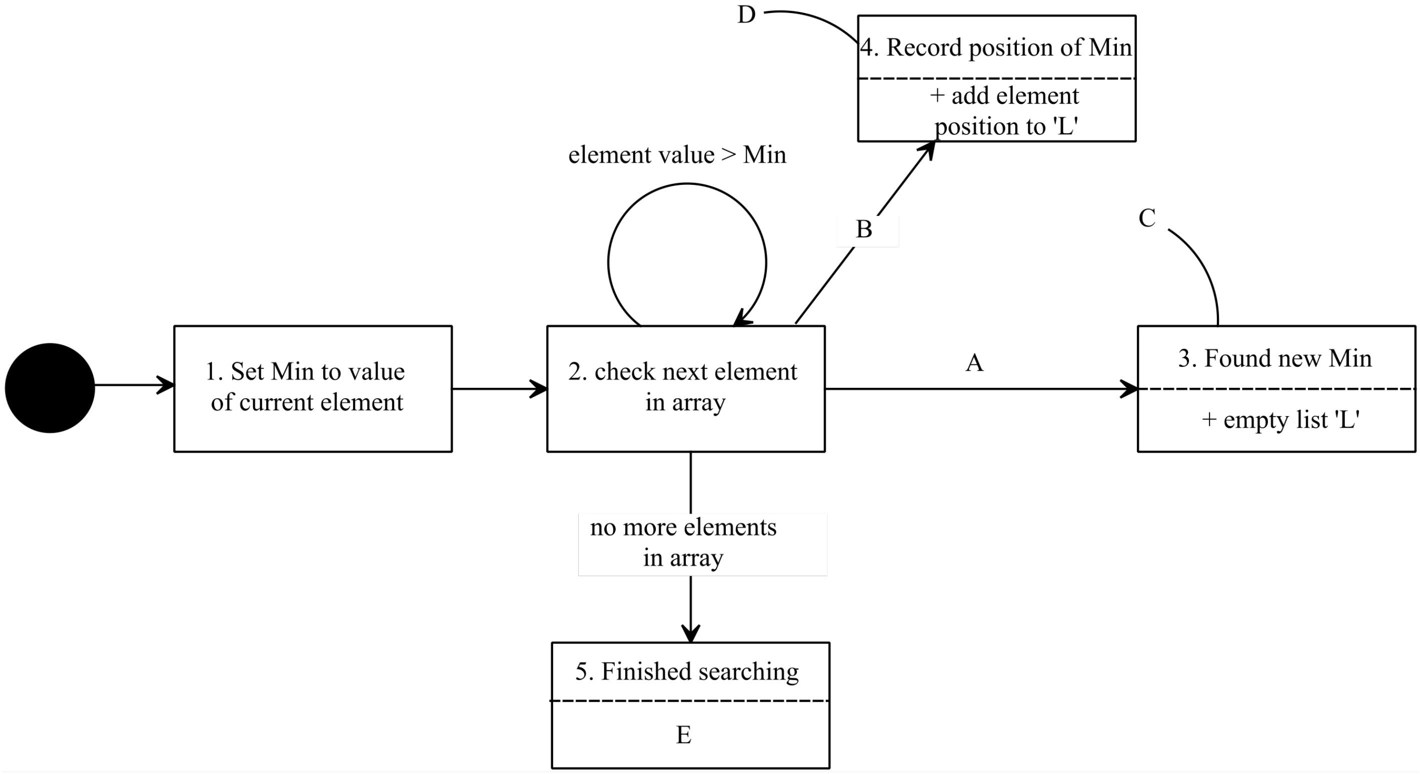
Pathways between nodes on a graph are modelled using specially coded DNA strands which only allow strands to combine if there is it is a valid pathway.	A1
Using natural processes, strands that begin and end at the correct starting node end up being replicated thus making these strands more common in the sample. Using gel electrophoresis, strands of the correct length (that visit the number of nodes in the graph) can be isolated and then strands that don't contain each node can be removed.	A2
The remaining samples will now represent all of the possible pathways through the graph and it only remains to determine the length of each pathway which can be done in linear time.	A3

Question 5 (8 marks**)**
In 1936 Alan Turing demonstrated that the Halting Problem was undecideable over Turing Machines. In the space below, describe the Halting Problem and explain Turing's argument that demonstrated that it is undecideable and the historical implications of this result.

The Halting problem is the problem of determining if a given algorithm with a given set of inputs will ever halt or not.	A1 & A2
Turing showed that it was not possible to find a solution to the Halting Problem through proof by contradiction. To do so, he first imagined that there was an algorithm, H, that could determine if an algorithm and its inputs would halt or not. He then constructed an algorithm that used H but would loop forever if the output of H was to say that the algorithm halted and that would halt if the output said that it would not halt. He then asked what would happen if you fed this algorithm into H and showed that if the algorithm ran forever, then H would determine that it would halt and vice-versa. The only logical conclusion that can be drawn from this contradiction is that it is not possible to find an algorithm H that can determine the halting problem.	A3, A4, A5 & A6
This was the first problem to be shown to be undecideable and ultimately led to the demonstration that Hilbert's Program was not possible.	A7 & A8

Question 6 (6 marks)
Konrad has been spending his holidays creating an algorithm that will find the minimum value of a 1-dimensional array of values and ouput what this value is AND it's location within the array. To help him understand how his algorithm works, he draws a state graph to represent the process followed by the algorithm.

The diagram below shows what Konrad has completed so far. The upper-case letters represent components that Konrad has not completed yet.



a. For the transition from state 2 to 3, what should Konrad write at A? 1 mark

Element value < Min	A1

b. If state 5 is reached, Konrad expects two actions to take place. What actions should take place at E? 2 marks

Action 1 –

Return Min	A1

Action 2 –

Return list L	A2

c. For the transition from state 2 to 4, what should Konrad write at B? 1 mark

Element value = Min	A1

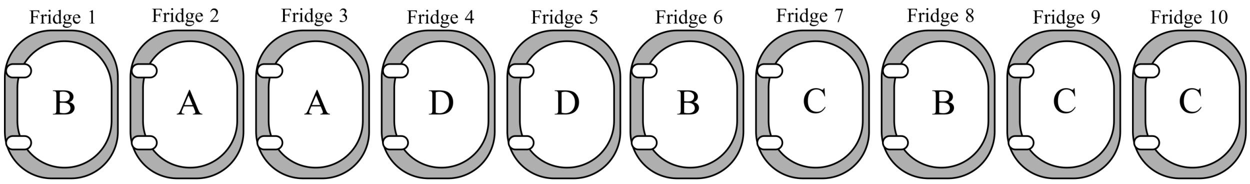
d. Konrad has started another transition labelled C. To which state should this transition go? 1 mark

4	A1

e. Konrad has started another transition labelled D. To which state should this transition go? 1 mark

1	A1

Question 7 (6 marks)
Saurabh and Rohan have been asked to help Benjamin arrange a collection of 10 containers that hold 4 different, highly infectious diseases, into a specific order. Each container is stored in it's own fridge to avoid cross-contamination of the diseases. These fridges are arranged in a line from left to right. The initial arrangement of diseases is shown in the diagram below.



The final arrangement of infectious diseases should be **AABBBCCCDD**.
Due to there only being 2 hazmat suits available and no empty fridges, Saurabh, Rohan and Ben can only move 2 diseases at a time, effectively swapping the location of the two diseases chosen in each movement.
Write an efficient algorithm in pseudocode that produces an end-state of diseases arranged in the order **AABBBCCCDD**.

Marks	1 - 2	3 - 4	5 – 6
Descriptor	An attempt to write an algorithm that will solve this problem has been made but algorithm is incomplete or will not lead to the correct solution.	Algorithm will lead to a correct solution to the problem but contains components that are not efficient and/or that do not identify when the solution has been reached and instead continue running for a fixed number of iterations.	Algorithm leads to correct solution and is an efficient attempt to solve the problem.

Question 8 (9 marks)

a. In the space below, outline John Searle's Chinese Room Argument and explain the implications of this argument? 4 marks

John Searle's Chinese room is an argument against the idea of strong AI or, artificial intelligence that is capable of understanding. John imagines a room in which an English speaking person is placed who cannot understand any Chinese. A native Chinese speaker outside the room passes written messages to the person inside the room. The person inside the room then uses a book that contains a set of instructions about how to respond to certain characters and follows these instructions to create a response that is then passed back to the person outside the room. The Chinese Speaker is satisfied by the response and so the person in the room passes the Turing Test however, the person inside the room has no understanding of what was being communicated.	A1 & A2
This is an analogy for what is happening inside a computer and John Searle argues that a computer can never understand what it is doing, it is simply following a set of rules.	A3 & A4

b. A common counter-argument to the Chinese Room Argument is known as the 'System's Reply'. In the space below, describe the 'System's Reply' response to the Chinese Room Argument. 3 marks

System's Reply suggests that while the individual in the room doesn't understand what is going on, the system as a whole does.	A1 & A2
This is akin to the idea that a single neuron in the brain doesn't understand what it is doing but the system of neurons that make up the brain do.	A3

c. John Searle also has a reply to the 'System's Reply' counter argument of the Chinese Room Argument. In the space below describe this reply. 2 marks

John Searle suggested that the person in the room could memorise all of the instructions from the book and then leave the room and still carry on appearing to understand Chinese but without actually understanding what is going on	A1
Thus he leaves the system behind but still does not understand what is going on so the system is not important.	A2

Question 9 (6 marks)
Compare a list, an array and an associative array. Use examples as part of your explanation.

A list is an unordered collection of elements that can only be accessed by looking at the first element in the list or the remainder (tail) of the list.	A1 & A2
An array is a 1 (or more) dimensional arrangement of elements which can be accessed and manipulated through knowledge of their index values.	A3 & A4
An associative array is an array of key-value pairs that allow you to reference a key which will then return the associated value.	A5 & A6

Question 10 (7 marks)
Yohan, Itay, Hugh, Shannon, Teagan and Germaine are working together to try work out the number of ways that they can walk up a set of *n* stairs if they can take either 1 step, or 2 steps at a time.
The begin by writing the following recursive function to generate the number of possible paths for *n* steps.

```
function StepCount(n)
        if n <= 2
            return n
        return StepCount(n – 1) + StepCount(n – 2)
```

a. Upon testing, Teagan realises that this function is not very efficient. Give a reason for why this might be the case 2 marks

This algorithm will repeatedly calculate the same things over and over	A1
For instance, in calculating StepCount(n-1), it will immediately recalculate the same value as StepCount(n-2)	A2

b. Hugh suggests that using a Dynamic Programming approach could work in this situation. How could Dynamic Programming be used to improve the efficiency of this algorithm? 3 marks

By storing each repeated value as it is first calculated	A1
And then recalling this value rather than recalculating it	A2
You can greatly reduce the total amount of time needed to find a solution to this problem by reducing the number of repeated operations	A3

c. What is a possible cost of using Dynamic Programming to improve the efficiency of this algorithm and why this is an acceptable cost in this case? 2 marks

Increased space complexity for storing the values as they are calculated (although this too can be minimised if you're clever)	A1
This is acceptable as the pay off in reduced time complexity is substantially better and space it generally easier to come by than time	A2

END OF QUESTION AND ANSWER BOOKLET