JOHN MONASH SCIENCE SCHOOL

VICTORIAN CERTIFICATE OF EDUCATION

2015

STUDENT NAME:

ALGORITHMICS (HESS)

Practice Exam 1

Tuesday 29th September

Reading Time: 15 minutes
Writing time: 120 minutes

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

Instructions for Section A

Answer **all** questions in pencil on the answer provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1

Which of the following are not examples of an abstract data type?

A. Lists
B. Graphs
C. Associative arrays
D. Pseudocode

Question 2

A brute force algorithm is

A. an algorithm which will force a solution to a problem to be given even when there isn't a valid solution to the problem.
B. a really robust algorithm that is difficult to break.
C. an algorithm that will find a solution to a problem by systematically generating and checking all possible solutions and then choosing the most appropriate one.
D. an algorithm which will always choose the most immediately beneficial outcome in the hope of reaching the optimal solution more quickly.

Question 3

Which of the following algorithms is commonly used to find the shortest path between any two pairs of nodes in a connected graph?

A. Floyd-Warshall's algorithm
B. Dijkstra's algorithm
C. Bellman-Ford's algorithm
D. Minimax algorithm

Question 4

Edge case identification is an example of

A. black box testing
B. white box testing
C. an algorithm design pattern
D. data modelling

Question 5

Consider the following recurrence relation:

$$T(n) = 2T\left(\frac{n}{2}\right) + O\left(n^2\right)$$

Which one of the following is the solution to the above recurrence relation using the Master Theorem?

A. $\Theta(1)$

B. $\Theta(n)$

C. $\Theta\left(n^2\right)$

D. $\Theta\left(\log_2(n)\right)$

Question 6

Prim's Algorithm is commonly used to

A. find the shortest distance between a single node and all other nodes in a graph.

B. generate the minimum spanning tree of a graph.

C. estimate the importance of a node based on its links.

D. sort an unsorted list into either ascending or descending order.

Question 7

An I.T. Professional is has been asked to monitor and, if possible, improve upon the way in which incoming I.T. problems and queries, of varying levels of urgency and importance, are dealt with by the I.T. Department.

The best abstract data type (ADT) to represent the processing of these problems and queries would be

A. a stack

B. a queue

C. a priority queue

D. an associative array

Question 8

Which of the following is useful for demonstrating the correctness of an algorithm?

A. identification of loop invariants

B. pair-wise testing

C. branch coverage

D. all of the above

Question 9

Which of the following statements regarding DNA Computing is incorrect?

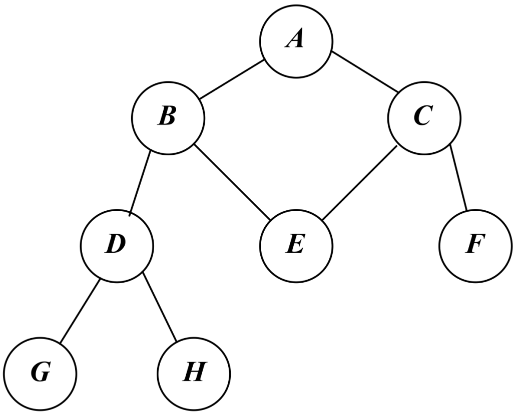
A. DNA Computing can be used to find solutions to any NP-Hard problem in polynomial time.

B. DNA Computing is essentially just massive parallel processing.

C. DNA Computing does not make an intractable problem like the Travelling Salesman Problem tractable.

D. DNA Computing can be considered to be equivalent to a Turing Machine.

Use the following information to answer Questions 10 and 11.



Question 10

Starting at node (vertex) *A*, the first 4 nodes visited by depth-first search are

A. *A, B, D, G*
B. *A, B, C, E*
C. *A, B, D, E*
D. *A, B, C, D*

Question 11

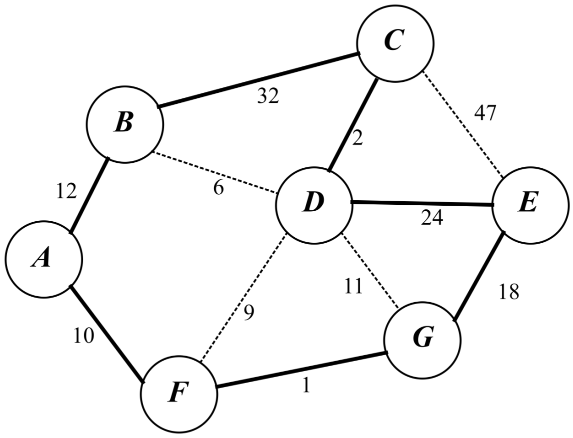
Starting at node (vertex) *A*, the first 4 nodes visited by breadth-first search are

A. *A, B, D, G*
B. *A, B, C, E*
C. *A, B, D, E*
D. *A, B, C, D*

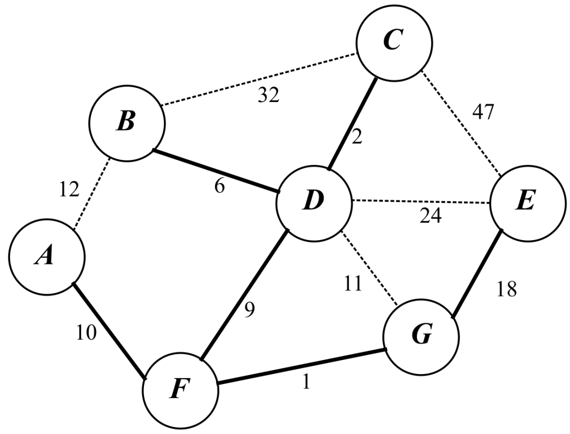
Question 12

Each of the diagrams below depict the same weighted graph.
Assuming that bolded edges represent a solution, which diagram shows the minimum spanning tree of this graph?

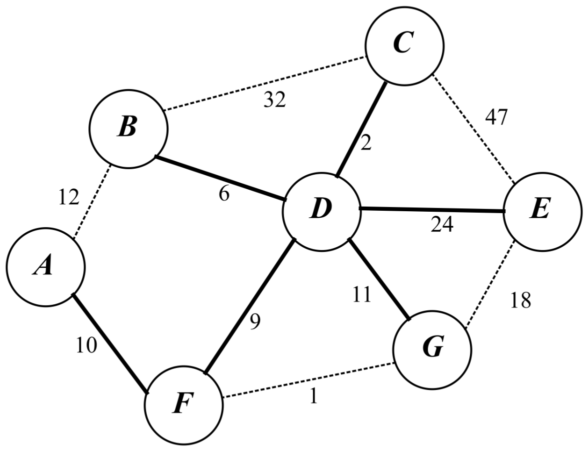
A.



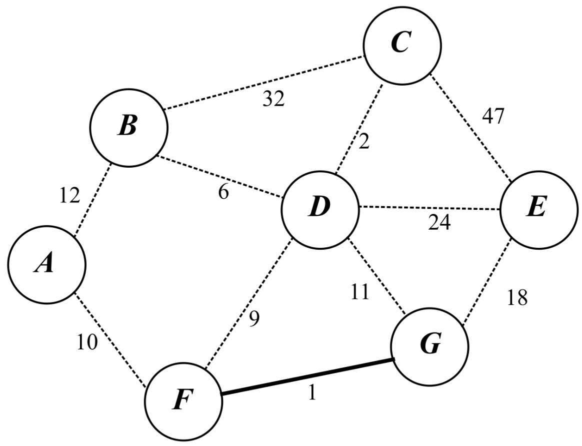
B.



C.



D.



Question 13

Which of the following shows the correctly ordered, from largest to smallest, time complexity in Big O notation?

A. $O(\log(n))$, $O(n)$, $O(\sqrt{n})$, $O(n^2)$, $O(n!)$,

B. $O(\log(n))$, $O(\sqrt{n})$, $O(n)$, $O(n^2)$, $O(n!)$,

C. $O(\sqrt{n})$, $O(\log(n))$, $O(n)$, $O(n^2)$, $O(n!)$,

D. $O(n)$, $O(\sqrt{n})$, $O(\log(n))$, $O(n^2)$, $O(n!)$,

Question 14

Which of the following algorithm design approaches can be described as
"an approach that recursively breaks down a problem into two or more sub problems until they become simple enough to solve, and then recombines the sub problems to provide a solution to the original problem."

A. Divide and Conquer
B. Dynamic Programming
C. Radomised Heuristics
D. Binary Search

Question 15

Which of the following statements is not true about NP-Hard Problems?

A. It is not possible to find a solution to an NP-Hard Problem.
B. All polynomial time complexity problems can be converted to NP-Hard Problems in polynomial time.
C. Use of processes such as DNA Computing can reduce the time complexity of NP-Hard Problems.
D. All of the above.

Question 16

The Halting Problem can be described as

A. a common problem with some algorithm designs that cause them to halt unexpectedly.
B. a famous problem posed by Alan Turing that showed that any algorithm carried out on a Turing Machine will eventually halt.
C. a famous problem in computer science regarding the determination of whether any given algorithm together with a set of inputs will halt or continue running forever.
D. a rare issue with some algorithm design patterns that causes algorithms to continue running forever.

Question 17

Randomised heuristics could be used to

A. find a near-optimal solution to the travelling salesman problem in polynomial time.
B. generate all possible states of a graph colouring problem in polynomial time
C. verify that a given solution is the optimal solution
D. all of the above.

Question 18

John Searle's Chinese Room is

A. A thought experiment proposed by John Searle that demonstrates how Strong Artificial Intelligence can never pass the Turing Test.
B. A thought experiment proposed by John Searle as a supporting argument for the possibility of Strong Artificial Intelligence.
C. A thought experiment proposed by John Searle as a counter argument for the possibility of Strong Artificial Intelligence.
D. A thought experiment proposed by John Searle to demonstrate the universality of computation.

Use the following information to answer Questions 19 and 20.

A Turing Machine is set up with the instructions shown in the following table, where each row represents one step of the machine and H is the halting state. It begins in state A.

Current State	Tape Symbol	Print Operation	Head Motion	Next State
A	0	1	right	B
A	1	none	left	B
B	0	1	left	A
B	1	none	right	H
H				

The machine is given the following tape. For this machine, the tape remains stationary while the head moves. The arrow shows the starting position of the head.

0	0	0	0	0	0	0	0	0	0
				↑					

Question 19

After the Turing Machine's first step, it will be in

A. state A and the head will be one position to the left
B. state A and the head will be one position to the right
C. state B and the head will be one position to the left
D. state B and the head will be one position to the right

Question 20

Which one of the following represents the tape's appearance and the position of the head when the Turing Machine halts?

A.

0	**0**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**
				↑					

B.

0	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**
				↑					

C.

0	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
				↑					

D.

0	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**
			↑						

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

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}

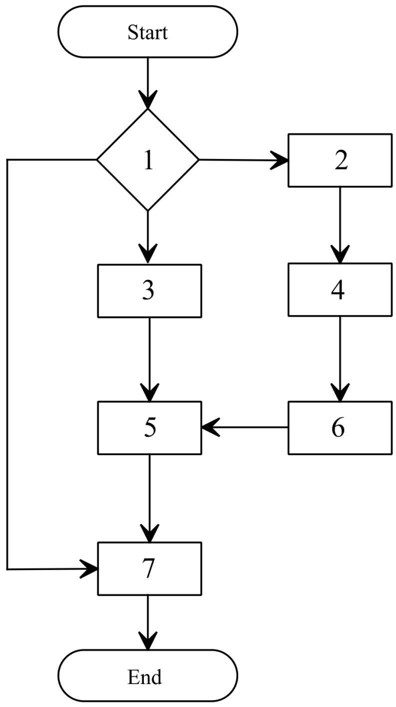
b. **i.** What is the total number of test cases Pavel is required to test if he wishes to test every possible combination of input values? 1 mark

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

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

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

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

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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

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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

___

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

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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

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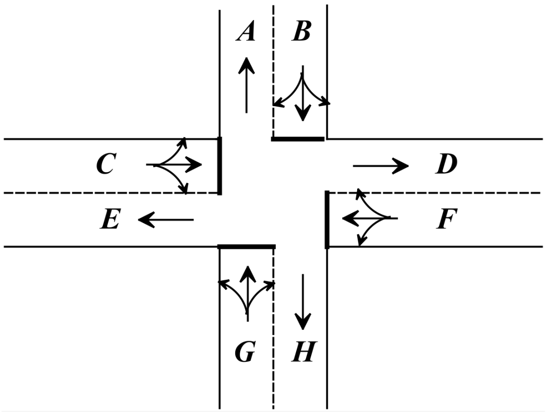
Question 3 (9 marks)
Alan is considering a career as a road designer. Near his house is an intersection like the one shown below.



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

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

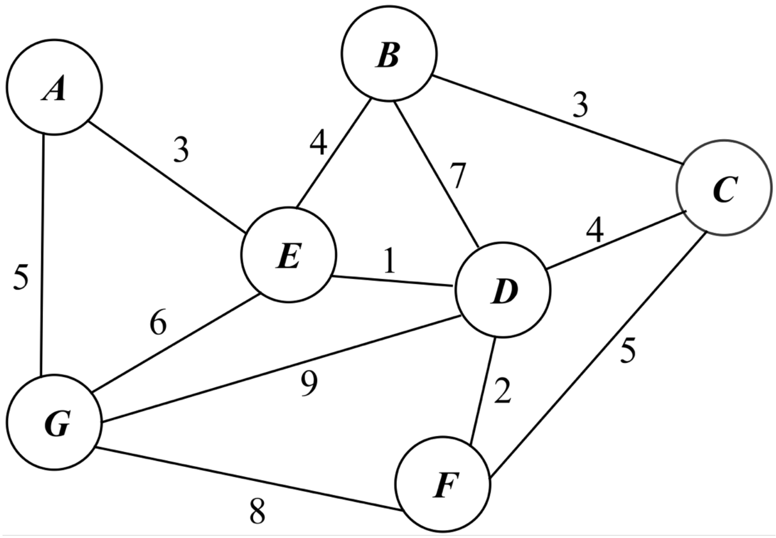
Property 1 ____

Property 2 ____

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

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.



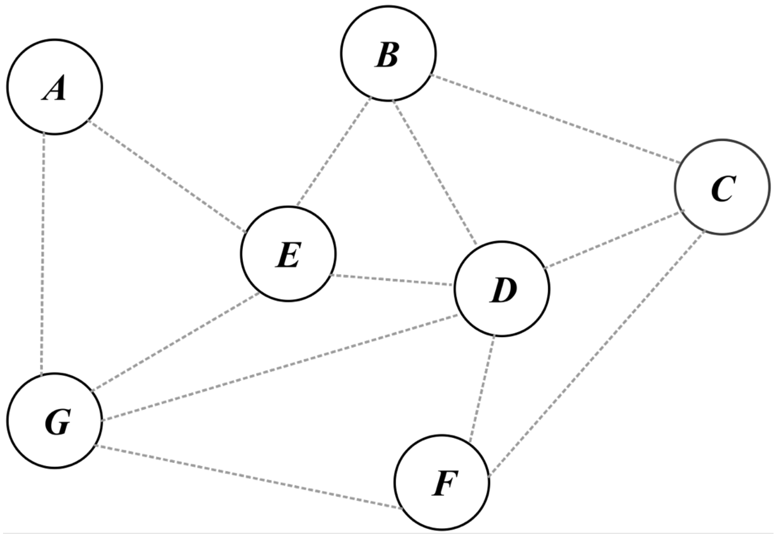
Ryan and Oliver are initially at node *A*.

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 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



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

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.

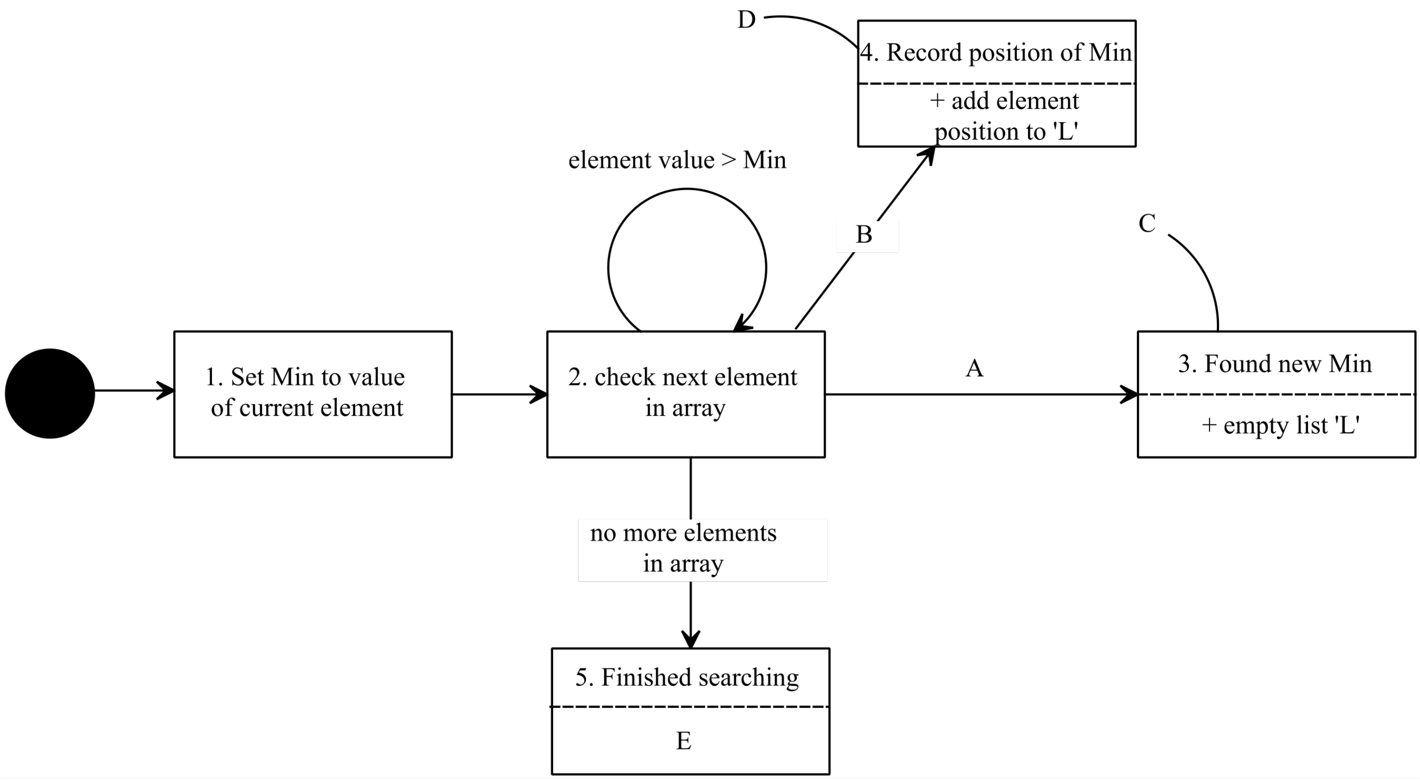
d. **i.** In the space below, explain the differences and similarities between DNA Computing and electronic forms of computing. 2 marks

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

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.

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

___

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

Action 1 - ___

___

Action 2 - ___

___

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

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

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

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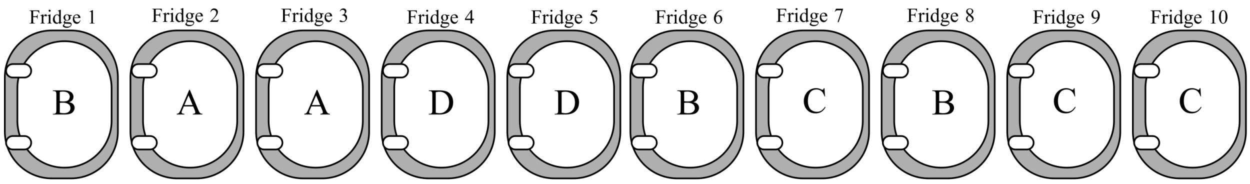
Question 7 (6 marks)
Saurabh and Rohan have been asked to help Benjamin arrange a collection of 10 containers that hold 4 different, highly infectious diseases, into a specific order. Each container is stored in it's own fridge to avoid cross-contamination of the diseases. These fridges are arranged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

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

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

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

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

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

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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

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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

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END OF QUESTION AND ANSWER BOOKLET