VICTORIAN CERTIFICATE OF EDUCATION

2021

STUDENT NAME:

TEACHER NAME: ALBD   BOHL

ALGORITHMICS (HESS)

Practice Exam 2

(Student Designed)

2021

Reading Time: 15 minutes
Writing time: 120 minutes

QUESTION AND ANSWER BOOK

Structure of book

Section	Number of questions	Number of questions to be answered	Number of marks
A	20	20	20
B	17	17	78
		Total	98

- 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 26 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 examination room.

SECTION A – Multiple-choice Questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet 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.

Use the Master Theorem to solve recurrence relations of the form shown below.

$$T(n) = \begin{cases} aT\left(\dfrac{n}{b}\right) + kn^c & \text{if } n > 1 \\ & \text{if } n = 1 \\ d \end{cases} \quad \text{where } a > 0, b > 1, c \geq 0, d \geq 0, k > 0$$

$$\text{and its solution } T(n) = \begin{cases} O(n^c) & \text{if } \log_b a < c \\ O(n^c \log n) & \text{if } \log_b a = c \\ O(n^{\log_b a}) & \text{if } \log_b a > c \end{cases}$$

Question 1

What are the imports in the signature specification of the priority queue ADT?

A.   Element and integer

B.   Element, integer and boolean

C.   Element

D.   Element and boolean

Question 2

The decision version of the knapsack problem is an example of what class of problems?

A.   P

B.   NP

C.   NP-Complete

D.   NP-Hard

Question 3
What most correctly defines a loop invariant?

A.   An algorithm that repeats the same process a given number of times or until termination.

B.   A formal statement about the relationship between variables in a program that holds

true, before and after the loop is run.

C.   A property that does not change

END OF QUESTION AND ANSWER BOOK

D. An algorithm that calls itself during implementation.

Question 4

Which of the following is **not** a standard response to the Chinese Room Argument?

A. The three stage robot reply

B. The systems reply

C. The neuron-by-neuron reply

D. The intuition reply

Question 5

Which one of the following statements is a correct reason as to why Dijkstra's Algorithm is not guaranteed to return a correct answer when run on a graph that contains a negative edge weight.

A. Dijkstra's algorithm might lock in a distance to a node before considering another path that is in fact shorter.

B. Dijkstra's algorithm will get caught in a loop resulting in the distance to all nodes being negative infinity.

C. The width of the graph cannot be calculated thus Dijkstra's cannot return a correct answer.

D. Dijkstra's will immediately terminate when encountering a negative edge weight.

Question 6

You are trapped in a maze. When represented on a graph; nodes represent junctions between paths in the maze and edges represent paths. Which of the following design patterns is the most appropriate method to find a way out of the maze?

A. Divide and Conquer

B. Decrease and Conquer

C. Randomised Heuristics

D. Backtracking

Question 7

What is a method of solving the Knapsack problem using Backtracking

A.   Selecting items and if the knapsack is full, taking an item out and trying another one

B.   Storing known solutions then trying to improve on them

C.   Using random methods to determine which combination of items work best

D.   Trying every single combination of items to find best solution

Question 8

A collection of trees is called

A.   A jungle

B.   A bush

C.   A forest

D.   A special tree

Question 9

Sukhman is trying to sell tickets for the Donda concert to a line of die-hard Kanye fans. Among those fans is Mr Bohni, and he is getting impatient. Sukhman decides to use an ADT to help speed up the process, and help Mr Bohni attend the concert as efficiently as possible. Which ADT should Sukhman choose to keep Mr Bohni happy?

A.   Graph

B.   Stack

C.   Decision Tree

D.   Queue

Question 10

In John Searle's Chinese Room, which of the following is assumed to be true?

A.   Chinese is read from left to right

B.   The program includes descriptions of the meaning of all Chinese characters

C.   Any Chinese characters can be matched to the instructions in the program

D.   The intelligence inside the room can read and understand Chinese characters

Question 11

Which of the following statements provides the best description of Mergesort and Quicksort?

A.   Quicksort has complicated merge and simple split. Mergesort has a complicated merge and complicated split.

B.   Quicksort has a simple merge and complicated split. Mergesort has a complicated merge and a simple split.

C.   They both have a complicated merge step but Mergesort has a simple split step.

D.   The both have a complicated merge step and Mergesort has a complicated split step.

Question 12

Which of the following is **not** considered a trade-off of using randomised heuristics?

A.   Space complexity

B.   Optimality

C.   Execution time

D.   Completeness

Question 13

Which of the following statements best describes an Eulerian Circuit?

A.   A path that traverses each edge in a graph exactly once

B.   A path that traverses each edge in a graph exactly once and ends where it started

C.   A path that traverse each node in a graph exactly once

D.   A path that traverses each node in a graph exactly once and ends at a node adjacent to where it started.

Question 14

"First in, first out" is most closely associated with which ADT?

A.   Queue

B.   Stack

C.   Dictionary

D.   Array

Question 15

Which of these combinations of specifications can only be found in a Dictionary ADT?

A.   Set, Get and Insert

B.   Create, Peek and Delete

C.   Add, Remove and HasKey

D.   Update, Append and IsEmpty

Question 16

How does Simulated Annealing work with Randomised Heuristics?

A.   By using random methods to find a solution

B.   There is a chance of accepting a worse solution when attempting to solve a problem

C.   Backtrack to a previous solution then generate another random solution.

D.   Use a depth-first search to discover all quantum gang gang possibilities and then
        sequence the best solution from there.

Question 17

Given an undirected, unweighted graph that has the edges: {(a,b), (b,c), (c,d), (a,d), (a,e)}, what
is the minimum number of colours that can be used to colour the graph so that no two adjacent
nodes are the same colour?

A.   1

B.   2

C.   3

D.   4

Question 18

Which of the following best describes the width of a graph?

A.   The largest weighted edge in the graph.

B.   The total weight of an Eulerian Circuit that spans across the whole graph.

C.   The total weights of the minimum spanning tree.

D.   The minimum distance required to be able to travel between any two nodes in the graph.

Question 19

What is a Hamiltonian Circuit?

A. A route that traverses each edge in the graph exactly once.

B. A route that traverses each edge in the graph exactly once and ends up at the same node at which it started.

C. A route that traverses each node in the graph exactly once.

D. A route that traverses each node in the graph exactly once and ends up at a node at which it adjacent to the node at which it started.

Question 20

Which one of the following ADTs are changed by the operators Push and Pop?

A. Stacks

B. Graphs

C. Queues

D. Lists

SECTION B

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

Question 1 (4 marks)

Matilda is running a commission service for paintings. Customers may request a painting for $12 and are offered an additional $10 'express painting' option (which guarantees quicker completion of the painting).

a.   Name an appropriate ADT that Matilda could use and how it would model the painting requests that she receives.   2 marks

_____

_____

_____

_____

_____

Matilda tires of the painting world and decides to enter the world of fast food. She ponders how she could model customers waiting to be served.

b.   What is an appropriate ADT that Matilda could use to model the order in which customers should be served at a fast food restaurant?   2 marks

_____

_____

_____

_____

_____

Question 2 (4 marks)

Paige is trying to travel between as many stores in a shopping centre as possible, in the shortest time possible.

She collects the following information regarding the travel time between stores:

To From	Spoolworths	Cotton Off	Big U	Pear Store	Badidas
Spoolworths	-	-	5	-	7
Cotton Off	10	-	8	6	-
Big U	13	7	-	12	-
Pear Store	-	16	-	-	3
Badidas	4	-	17	-	-

Create a graph to represent the provided information about the shopping centre.

Question 3 (8 marks)

A teacher goes to collect the papers for the students latest assignment and is figuring out how to go through and mark them all

a.   Name an appropriate ADT that they could use   1 mark

b.   Some of her students need their results back early to apply for another course. Describe a new specification for the ADT named in part **a.** that will allow the teacher to accommodate this new requirement. As part of your answer, explain how the new operation could be implemented.   2 marks

Question 4 (3 marks)

Wei's hat store has run into a problem: All the hats are out of order. Wei would like to sort them based on their size.

Write pseudocode for an algorithm that will take as input a list of hats and their sizes and that will return the list of hat sorted from smallest to largest.
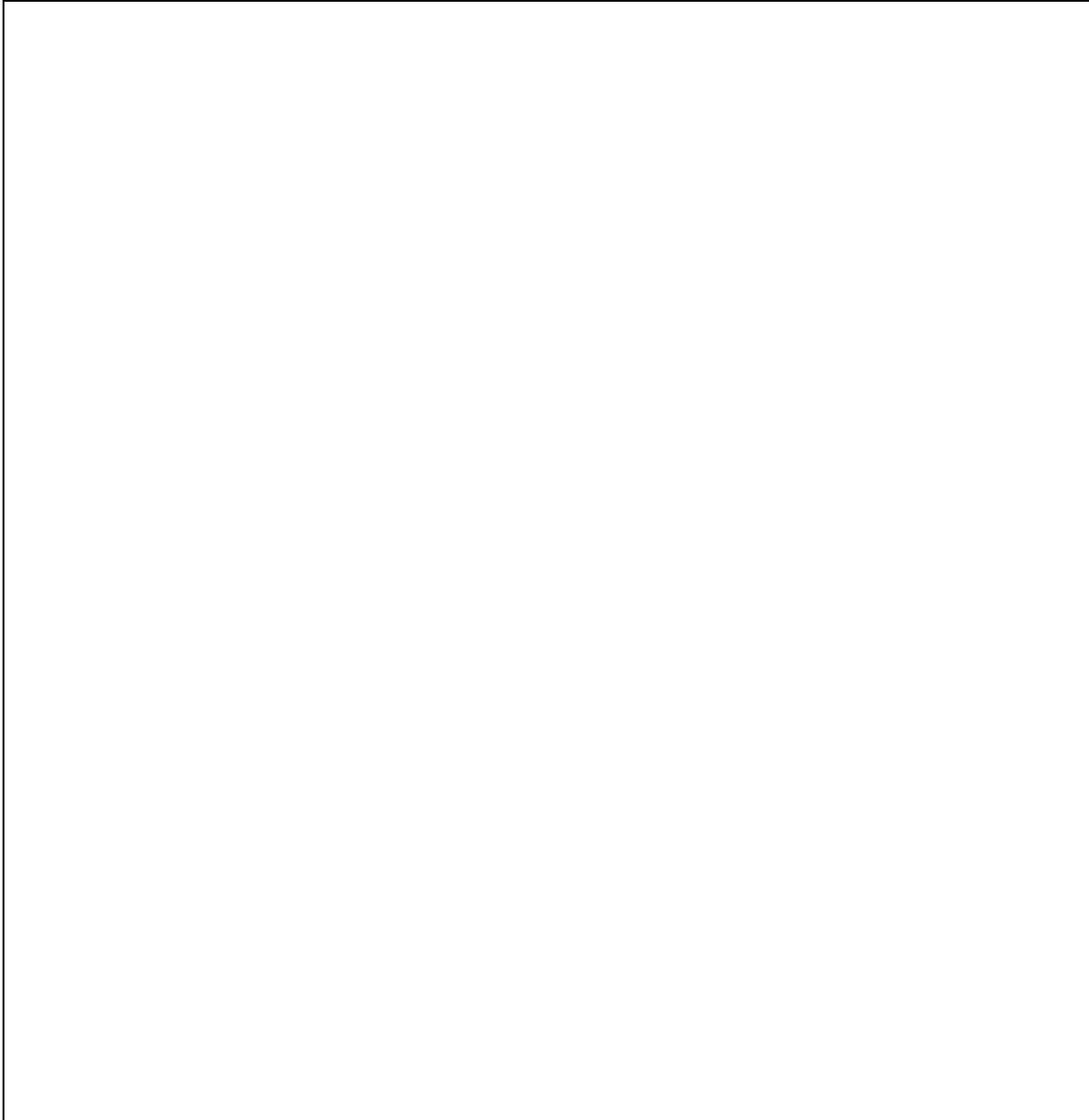
Question 5 (3 marks)

Describe the method by which the Minimax algorithm attempts to find an optimal solution.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 6 (3 marks)

Write pseudocode for an algorithm, that utilises dynamic programming, to find the nth
Fibonacci number.

Question 7 (4 marks)

Prove the correctness of this Algorithm that returns the square of the input, n.

```
S ← 0
i ← 0
while i < n
  S ← S + n
  i ← i + 1
return S
```

Question 8 (5 marks)

Use induction to prove that the sum of the first n odd numbers is equal to n^2.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 8 (5 marks)

Use induction to prove that the sum of the first n odd numbers is equal to n^2.

Question 9 (3 marks)

Ben is trying to keep track of who interacted with each other in the GAT to model the spread of a rumour after 2 gossip spreaders went into the exam.

a.   Describe a suitable ADT that could be used to model this task and how it could be used to store the information.   1 mark

A primary recipient is someone who has been told the rumour by one of the gossip spreaders. A secondary recipient is someone who has been told the rumour by a primary recipient.

b.   Rob suggests that to sort people into primary and secondary recipients, Dijkstra's algorithm would be best because it has a time complexity of $O(n\log(n))$. Discuss the suitability of Dijkstra's algorithm for this task.   2 marks

Question 10 (2 marks)

Euler stated that there was no solution to the Konigsberg Bridge Problem. What conditions did Euler say must be satisfied for an Eulerian Trail to exist?

_____

_____

_____

_____

_____

_____

_____

Question 11 (6 marks)

Consider the following list L = {cookie, cake, brownie, penguin, cow, sheep, goat}.

a.   Which element is referred to when we say L[3]?   1 mark

_____

_____

b.   State the appearance of L after each of the following operations are carried out.   5 marks

1. L.append(pig)
2. L.prepend(cup)
3. L.get(L[1])
4. L.set(L[4], rabbit)
5. L.delete(L[0])

_____

_____

_____

_____

_____

Question 12 (3 marks)

Aden lives in a cave system where he is tortured every day, suffering for eternity or until the end of this practice exam… whichever comes sooner.
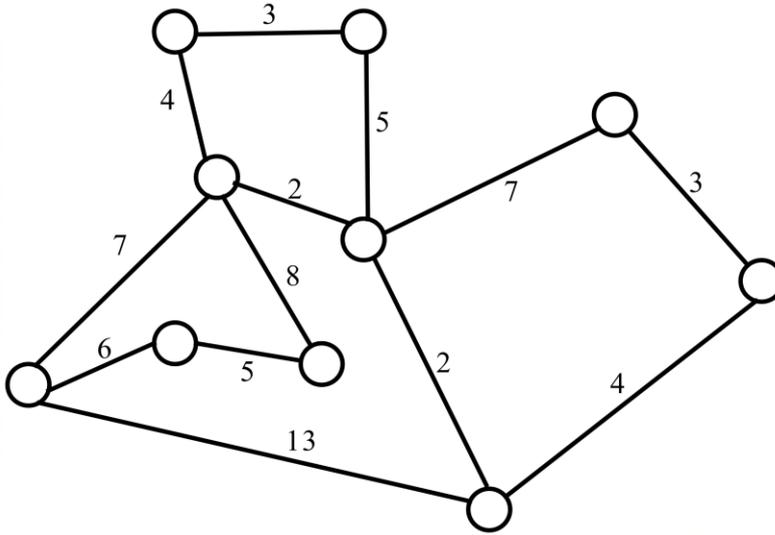
Aden wishes to find the minimal spanning tree of his cave system.

a.   Describe what a minimal spanning tree is.   1 mark

b.   Construct a minimal spanning tree for Aden's cave system.   2 marks

Question 13 (4 marks)

Professor Bohni was writing a scientific paper on the uses of minimax in turn-based games. However, he has tripped and bumped his head after too many monkeys jumped on the bed so the doctor said, 'I'm sorry professor, you've messed up your head'. It's such a shame. The paper was nearly complete. If only **somebody** could help Professor Bohni finish his paper.

For the following games, state and explain with reasons why minimax would or would not be appropriate to use to help choose the best move to make.

a. Chess   1 mark

_____

_____

_____

b. Tic-Tac-Toe   1 mark

_____

_____

_____

c. Connect-4   1 mark

_____

_____

_____

d. Rock-Paper-Scissors   1 mark

_____

_____

_____

Question 14 (5 marks)

A student and close apprentice of Professor Bohni, Student Sharan, was too busy training for his baki physique and did not hear about Professor Bohni's blunder. After paying off so many freelancers to write his New York Times Best Selling Novel of 2043 'Algorithmics for dummies', he had gone broke. Sharan accidentally signed off his royalties to scam artist Julee-Ann and has no way to pay off the freelancers for a second novel. To make up for this, Sharan had the grand idea of hiring homeless people to run errands for him around the neighbourhood, checking everyone's house for Amazon Deliveries to snag. A new job, a new beginning. However, Homeless Amish is worried that his loan shark Kody will be mad if he does not make enough money before the deadline. He wishes to complete this trip as fast as possible.

Help Homeless Amish plan the fastest route before he becomes fish sticks for Loan Shark Kody.

a. Describe the NP-hard version of the travelling salesman problem.   2 marks

b. Explain how Amish could make use of Randomised Heurtistics to assist him in finding the solution to the travelling salesman problem. As part of your answer discuss the optimality of the solution this approach would supply.   3 marks

Officer Shiann's most recent investigation has been giving her migraines as of late after having trouble finding evidence for Homeless Amish's arrest. She had been tipped on Homeless Amish's or rather Criminal Mastermind Amish's next movements. Upon arrival at his next location, Shiann felt uneasy. It was a long abandoned school left since 2021, John Monash Science School. She had suffered trauma from all the SACs and exams that took place here but she could not fret. She had to continue.

'All mine… ALL MINE!', Criminal Mastermind Amish cackled.

'On the ground! This is the Shiann under authorised investigation of Amish! ON THE GROUND', Shiann exclaimed.

'Not so fast'

'You have the right to be silent!', she exclaimed again.

'That wasn't me', Criminal Mastermind Amish whimpered

'Well well well' A figure clapped, 'lookie here, Officer Shiann.

'YOU! I knew you were a part of this! You're both under arrest!', Shiann retaliated

Jumping down 20 meters off the stairs of the school Mafia Boss Kody emerged from the darkness.

'OH REALLY? I'd like to see you try', Mafia Boss Cody cackled, 'See this place has been booby trapped from the top to the bottom! Best watch where you step'

Using Officer Shiann's high tech police gear, she whips out her inspectionaliser 3000 and scans the room for the booby traps, turns out booby traps are placed in a square pyramidal sequence where the safe spots are the spaces between those square pyramidal numbers.

The first few square pyramidal numbers are 1, 5, 14, 30, 55, 91 and 104 and can be visualised with the following diagram.

| 1 | 5 | 14 | 30 | 55 |
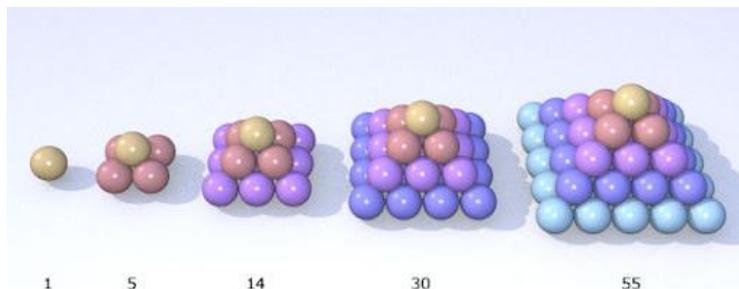
Suddenly, her inspectionaliser 3000 ran out of battery.

'I told him to charge it', she groaned, ', I'm coming after you, Greek God Bod Sharan when I'm through with this.

Turns out Sharan forgot to charge after he borrowed it to analyse his body.

Officer Shiann, who now manually has to figure out this problem needs help.

Question 15 (3 marks)

Outline a dynamic programming approach that Shiann could use to find pyramidal numbers to the nth sequence.

Question 16 (5 marks)

Mr Bohni is in a rush to get to his favourite coffee shop before his lunch break runs out, but his GPS is malfunctioning hence has to reprogram it using graph theory.

a.   Explain what his graph would represent, and what algorithm he could use to find the shortest cost to his favourite coffee shop, explain your choice   3 marks

_____

_____

_____

_____

_____

_____

_____

_____

b.   A one-way wormhole has appeared to the coffee shop, giving him extra "cost" to spare, how would this affect the graph, and would you still use Dijkstra's, if not what other alternatives would you choose.   2 marks

_____

_____

_____

_____

_____

_____

_____

_____

Question 17 (8 marks)

Dr Albrecht is attempting to tile his new bathroom with a unique tile shape.

board   tromino
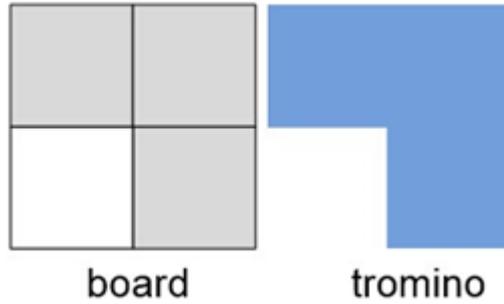
He wishes to tile his 16 x 16 square bathroom but is unsure if this is possible given the tile's unusual shape.

Determine the viability of this tiling and explain how the following algorithms would reach a solution.

a.   Backtracking   2 marks

_____

_____

_____

_____

_____

b.   Divide and Conquer   2 marks

_____

_____

_____

_____

c.   Decrease and Conquer   2 marks

_____

_____

_____

_____

d. Brute Force   2 marks

Question 17 (5 marks)
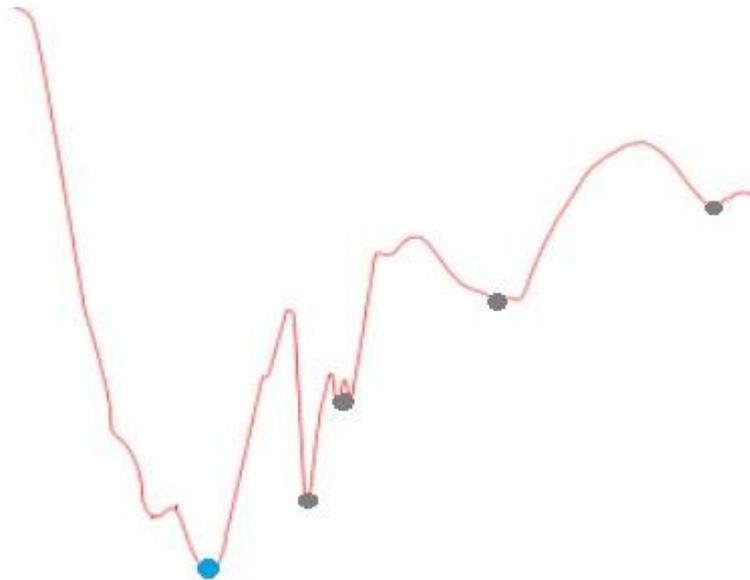
Professor Bohni finally awakens after knocking his head. But what's this? It seems he has become delusional and has sleep-walked into the middle of a mountainous desert. A large valley between sand dunes is in front of him. As he has been unconscious for many days, he is extremely dehydrated. He knows that somewhere in the valley, at the **lowest altitude**, lies an oasis with a river where Professor Bohni can quench his thirst. By modelling the valley using the above graph, using his advanced algorithmic skills, Mr Bohni knows he can calculate the exact location of the river using randomized heuristics.

a. Describe the basics of how randomised heuristics work and why it is useful.   2 marks

b.   Explain how randomised heuristics could be applied to this specific problem. Ensure you include in your answer which algorithmic design component randomised heurists rely on that will result in the blue point being found instead of the grey points.   2 marks

_____

_____

_____

_____

_____

c.   Is randomised heuristics guaranteed to find the location marked with the blue dot?   1 mark

_____

_____

_____

_____

_____

SECTION A - continued