JOHN MONASH SCIENCE SCHOOL

VICTORIAN CERTIFICATE OF EDUCATION

2015

STUDENT NAME:

ALGORITHMICS (HESS)

Practice Exam 2

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

END OF SECTION A
TURN OVER

SECTION B

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

Question 1 (15 marks)

Bartholomew Highlander enters a jungle and finds many clearings and pathways connecting those clearings. He leans down and picks up a map that is on the forest floor. The map states that there is a diamond buried under one of the clearings. He finds that it takes a certain amount of time to follow each path. Assume that there are a series of paths that allow Bartholomew to reach the diamond.

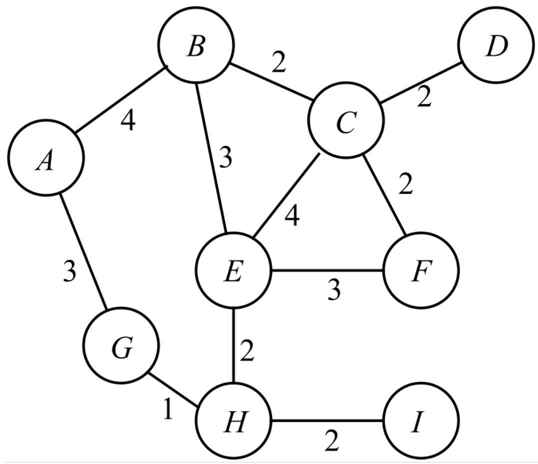
a. State and define 2 appropriate ADT's that Bartholomew Highlander can use to model the jungle. Explain the advantages and disadvantages of using each ADT. Also write their specifications 4 marks

Graph ADT - add edge - add node - get neighbours - get edge weight … Good to be able to visualise and see the connections between attributes of the model	A1 & A2
Array ADT - add element - check element - remove element … Easy to manipulate and/or change aspects of the model	A3 & A4

b. Explain what is meant when it is said that these ADT's allow Bartholomew's problem to be abstracted and modularized. 1 mark

Irrelevant information is removed from the model, leaving only the parts that are important or of interest to solving the problem.	A1

When Bartholomew Highlander uses one of the ADT's mentioned above to model the paths and clearings, he ends up with the diagram below:



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

10	A1

Bartholomew Highlander asks himself how he can find the path of minimum time to the diamond. "How would I do this… Oh I know, I find the time required to follow every possible non-cyclic path, and then find the minimum time"

d. Starting at node *A,* perform breadth first search on the graph and record the order in which each node is visited until the clearing with the diamond (node *F*) is found. 2 marks

A→B→G→C→E→H→D→F *deduct ½ mark for every error and round down to a maximum of 2 marks	A1 & A2

e. Starting at node *A,* perform depth first search on the graph and record the order in which each node is visited until the clearing with the diamond (node *F*) is found. 2 marks

A→B→C→D→F *deduct ½ mark for every error and round down to a maximum of 2 marks	A1 & A2

f. Explain which approach would be more appropriate for Bartholomew Highlander to use to find the shortest path to the diamond and justify your answer. 2 marks

Depth First Search	A1
Because it will reach node F first in this case	A2

"I can do better than this" thought Bartholomew. What if I used the Bellman Ford algorithm?

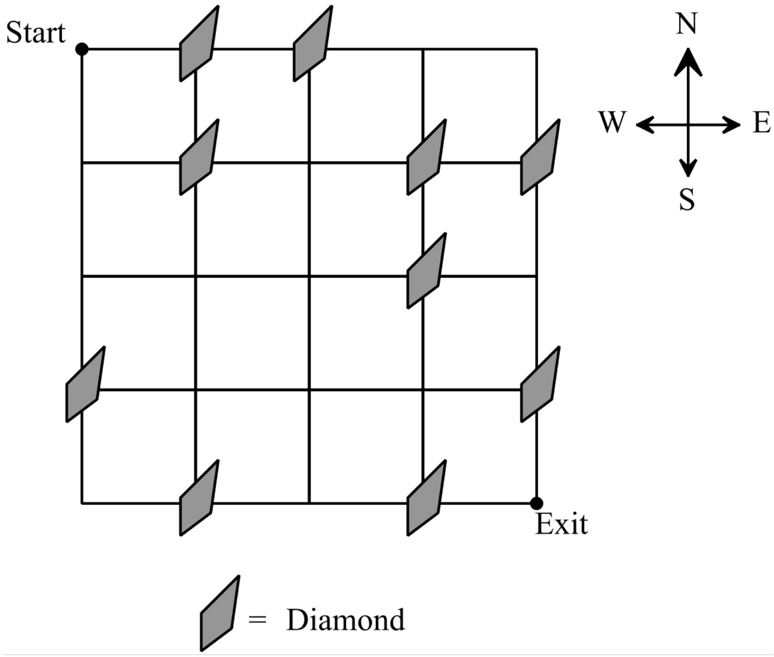
g. Explain why the Bellman Ford algorithm is not the most efficient algorithm to use in this case and identify a situation where this algorithm would work best and explain why. 3 marks

Bellman Ford is used to find the shortest path between a specific node and all other nodes in the graph	A1
It uses relaxation of edges to ensure that it finds the shortest path which assists with dealing with negative edge weights	A2
It has a higher time complexity as a result however and so is not very efficient for this particular problem.	A3

Question 2 (7 marks)

Bartholomew stumbles upon an ancient burial ground that is littered with large diamonds. Flabbergasted by the beauty of all these diamonds, he sits down to think about his current dilemma and in the process, loses his shoes. Due to the number of insects and venomous snakes in the burial grounds, he decides to make a quick dash across the burial ground whilst collecting as many diamonds as he can.

Because of all of the graves in the gravesite, Bartholomew is restricted to only moving East or South towards the exit. The diagram below models Bartholemew's situation.



a. Explain how a heuristic could be used to attempt to solve this problem and outline the limitations such an approach could have towards finding the optimum solution. 2 marks

Heuristic - Always move towards the closest junction that contains a diamond	A1
This heuristic approach is a greedy approach and while it chooses the path that is most immediately beneficial at each step, it could miss a more optimum solution that would be found through making a worse choice earlier on.	A2

Bartholomew decides to instead use a dynamic programming approach to find the optimum pathway through the burial ground.

b. Explain what dynamic programming is and the benefits and disadvantages of using such an approach. 3 marks

Dynamic Programming involves storing the values of calculations that are carried out repeatedly	A1
And then recalling these values instead of recalculating them, thus reducing the time complexity of the algorithm	A1
A disadvantage of this approach is that it could increase the space complexity of the algorithm by requiring the values to be stored somewhere.	A1

Bartholomew draws a quick map of the burial grounds, representing the locations of diamonds with 1's and the all other locations with 0's.

0	1	1	0	0
0	1	0	1	1
0	0	0	1	0
1	0	0	0	1
0	1	0	1	0

He then uses the DiamondCollector Algorithm described in pseudocode below:

```
DiamondCollector(C[1…n , 1…m])
F[ 1 , 1 ] ← C[ 1 , 1 ]
for j = 2 to j = m
        F[ 1 , j ]  ← F[ 1 , j - 1 ] + C[ 1 , j ]
For i = 2 to i = n
        F[ i , 1 ] = F[ i - 1, 1 ] + C[ i , 1 ]
        for j = 2 to j = m
                F[ i , j ] = Maximum value of ( F[ i - 1, j ] or F[ i , j - 1] )  +  C[ i , j ]
return F[ n , m ]
```

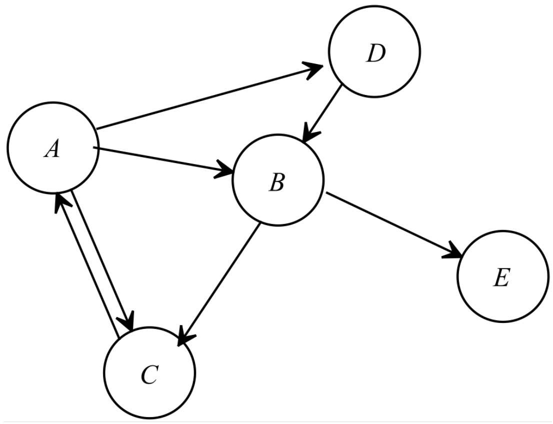
c. On the diagram below, draw the path that would be found using this algorithm. 2 marks

0	1	2	2	2
0	2	2	3	4
0	2	2	4	4
1	2	2	4	5
1	3	3	5	5

Correct values *deduct ½ mark for every error and round down to a maximum of 2 marks	A1
Correct pathway (note that there are more than the one shown)	A2

Question 3 (7 marks)

Consider the following graph that represents five web pages. Edges represent which websites reference each other through use of a directed edge pointing towards the website being referenced.



a. Outline how the PageRank algorithm works in terms of how it interacts with the website graph (above), and how it is used for ranking web pages. 4 marks

Pagerank ranks pages in order of increasing importance by looking at how often the page is being referenced by other pages.	A1
It begins by assigning each page (or node) an equal value	A2
And then it distributes each node's weighting value equally amongst the nodes which it references	A3
Once this is done, it then repeats the process but with the new weighting values assigned after the first iteration. It will do this a number of specified times to determine the ranking of each page.	A4

b. Assuming a dampening constant of 0.85, determine the ranking of each website after one iteration of running Pagerank on the graph shown above. 4 marks

$PR(A) = \frac{1-d}{N} + d\left(\frac{PR(B)}{L(B)} + \frac{PR(C)}{L(C)} + ...\right)$	A1
PR(A) = 0.2 PR(B) = 0.26 PR(C) = 0.17 PR(D) = 0.087 PR(E) = 0.115 PR(E) = 0.115 Deduct ½ a mark for each incorrect value and round down.	A2 & A3 & A4

Question 4 (4 marks)

Outline the differences and similarities between bottom up and top down design of algorithms. 4 marks

Bottom Up design involves the designing of systems or algorithms from specific parts of the problem and then combining them together into a more complex system to solve the whole problem	A1 & A2
Top Down design involves starting with a general approach to solving the problem and then redefining and improving each section to make it more specific or accurate until the whole system works.	A3 & A4

Question 5 (4 marks)

a. Use quicksort to sort the following list. Indicate the pivot chosen. 2 marks

List								**Pivot**
1	5	1	6	9	2	-3	7	**7**
1	**5**	**1**	**6**	**-3**	**2**	**9**	**7**	**7**
1	**5**	**1**	**6**	**-3**	**2**	**7**	**9**	**2**
1	**-3**	**1**	**6**	**5**	**2**	**7**	**9**	**2**
1	**-3**	**1**	**2**	**5**	**6**	**7**	**9**	**1**
-3	**1**	**1**	**2**	**5**	**6**	**7**	**9**	**1**

b. Compare the quicksort and mergesort sorting algorithms, in terms of their time complexity and a their design approach to sort items 2 marks

Quicksort has an average case time complexity that is better than mergesort but both have the same worst case time complexity	A1
Mergesort and quicksort are both examples of a divide and conquer approach to solve the problem but mergesort is more stable and reliable than quicksort.	A2

Question 6 (8 marks)

Outline how DNA computing works and it's implications for solving traditionally intractable problems

DNA Computing is basically large scale parallel processing.	A1
Initially, a model is created that uses different sequences (or strands) of DNA molecules to represent aspects of a problem (say paths between nodes on a graph)	A2
By using the natural processes and characteristics of DNA, it is possible to generate, with high probability, all possible combinations of connections between these nodes by then mixing the DNA Strands together.	A3 & A4
With some manipulation of the strands to remove paths that are undesirable (eg: too long or containing multiple versions of the same path), it is then possible to identify the optimum solutions in linear time from the solutions generated using DNA.	A5 & A6
However, intractable problems will still remain intractable even with use of DNA computing techniques although the time complexity has been reduced through use of DNA and so slightly larger problems can be solved that couldn't have been solved otherwise.	A7 & A8

Question 7 (10 marks)

a. Outline John Searle's Chinese Room Argument and explain it's implications for computer science. 6 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. Provide and explain two counter arguments to the Chinese Room Argument. 4 marks

Argument 1 –

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
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.	A2

Argument 2 –

Other Minds Reply suggests that John Searle's argument for consciousness is not well defined	A3
And that he is holding the room to a higher standard than is reasonably expected to be applied to anyone else and that given we can only base our opinions on the observed behaviour of the room, since it exhibits behaviour consistent with consciousness, should be considered conscious.	A4

Question 8 (11 marks)

a. What do the classifications of problems P, NP, NP-Hard and NP-Complete mean? Give examples of algorithms for each classification. 8 marks

P – A problem that can be solved in polynomial time	A1
P example – sorting a list	A2
NP – A decision problem that cannot be solved in polynomial time but can be verified in polynomial time	A3
NP example – is there a path through a graph, visiting every node, with distance less than *k*	A4
NP-Hard – A problem that is at least as hard as an NP-complete problem (not necessarily a decision problem)	A5
NP-Hard example – Travelling Salesman Problem	A6
NP-complete – A decision problem that cannot be solved in polynomial time but that can be verified in polynomial time and to which an NP problem can be converted to in polynomial time.	A7
NP-complete example – Graph Colouring Problem	A8

b. Explain the implications for computer science, if a problem proven to be NP complete can be solved in polynomial time. 3 marks

Because it is possible to reduce any NP or NP-Hard problem to an NP-complete problem in polynomial time	A1
If it is shown that P=NP, then it is possible to solve any NP problem in polynomial time	A2
This would have implications for things like encryption where it would then become possible to crack a given code in polynomial time.	A3

Question 9 (4 marks)

a. Find the time complexity of the following algorithm. 2 marks

```
function Sum2(x):
    sum ← 0
    if(x > 1):
        for i = 0 to x-1:
            for j = 1 to x
                sum ← sum + i + j
    else:
        // 1 operation
        return sum
```

$\sum_{i=0}^{x-1}\sum_{j=1}^{x}1$	A1
$O(n^2)$	A2

b. Given the algorithm's complexity that you found in part **a.**, for what values of n will this algorithm be more efficient than another algorithm which does the same thing but with time complexity of $O(2^n)$? 2 marks

$n^2 = 2^n$	A1
$n = 1$ or $n = 2$ $\therefore$ for values of $n \geq 2$, the first algorithm will be more efficient	A2

Question 10 (8 marks)

a. List the main components of a Turing Machine and describe their purpose. 2 marks

Tape – infinitely long containing either a 1 or a 0 at each section of the tape Reader – reads the value on the current section of tape Writer – Erases and writes either a 0 or a 1 in each section of the tape *deduct half a mark for each omission or incorrect statement and round down to a maximum of 2 marks.	A1 & A2

b. A Turing Machine can perform 5 different actions. What are these 5 actions? 2 marks

Move Left Move Right Write Change State Halt *deduct half a mark for each omission or incorrect statement and round down to a maximum of 2 marks.	A1 & A2

c. Complete the following sentence and describe a thought experiment that demonstrates the statement. 2 marks

Since the Halting problem is ____________________________it suggests that automatic program verification is not tractable.

Undecidable	A1
Turing proposed a thought experiment that demonstrated that the halting problem was undecidable. He began by assuming that there was a machine H that could determine whether a given algorithm with inputs, would halt or run forever. He then created a M machine that contains H but that takes the output of H and, if it says halt, will loop forever and if it says runs forever, will halt. He then fed M into H which led to a contradiction as H would say that M will halt when it loops forever and that it will loop forever when ever it halts. Turing thus showed that the machine H could never exist.	A2

END OF QUESTION AND ANSWER BOOKLET