JOHN MONASH SCIENCE SCHOOL

VICTORIAN CERTIFICATE OF EDUCATION

2015

STUDENT NAME:

ALGORITHMICS (HESS)

Practice Exam 2

2015

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 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 1

Which one of these is the **correct** order of decreasing time complexities?

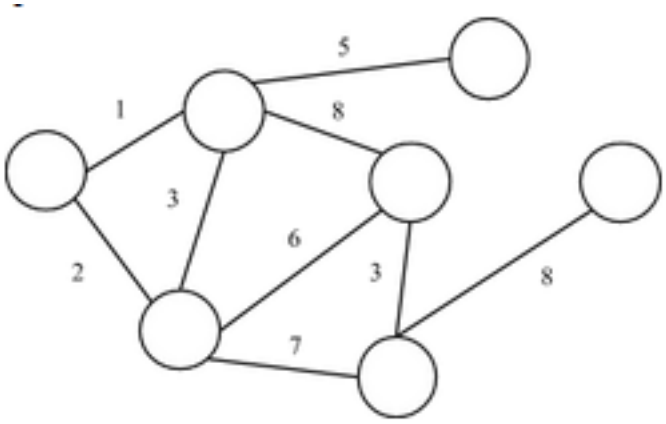
A. $O(n^2)$, $O(n)$, $O(n\log(n))$
B. $O(n)$, $O(n^3)$, $O(n\log(n))$
C. $O(n\log(n))$, $O(n)$, $O(n^2)$
D. $O(n^3)$, $O(n^2)$, $O(n)$

Question 2

The Bellman Ford algorithm and the Floyd-Warshall algorithm have a design principle of

A. Dynamic programming
B. Dynamic programming and Brute force respectively
C. Brute force and Dynamic programming respectively
D. Top-down design and bottom up design respectively

Question 3



The largest spanning tree of the graph above has a width of

A. 25
B. 19
C. 36
D. 15

Question 4

Which one of the following statements is **false**?

A. The Bellman Ford algorithm and the Floyd Warshall algorithm can deal with negative edges
B. The Floyd Warshall algorithm uses dynamic programming whilst the Bellman Ford algorithm uses relaxation
C. Dijkstra's algorithm can sometimes work for negative edges
D. The Floyd Warshall algorithm uses relaxation whilst the Bellman Ford algorithm uses dynamic programming

Question 5

The **difference** between a stack and a queue is:

A. a queue is a list while a stack is not a list
B. there is no difference
C. the first element in a stack is served first while the last element in a queue is served first
D. the last element in a stack is served first while the first element in a queue is served first

Question 6

Which of the following statements about DNA computing is **false**? DNA computation...

A. solves the travelling salesman problem in polynomial time
B. is limited in computability to a turing machine
C. cannot solve all NP hard problems in polynomial time
D. is limited by the number of DNA strands

Question 7

Which one of these **best** defines loop invariants?

A. Conditions that are always true before and after each iteration of a loop
B. A form of technique used to prove correctness of algorithms
C. Statements that are repeatedly called a fixed number of times
D. All the above

Question 8

You have been given a triangle of numbers (as shown). You are supposed to start at the apex (top) and go to the base of the triangle by taking a path downwards.
What is the minimum sum of such a path?

75
95 64
17 47 82
18 35 87 10
20 04 82 47 65

A. 209
B. 225
C. 386
D. 390

Question 9

Using master theorem, find the time complexity of the following recurrence relation $T(n) = 4*T(n/2) + n$

A. $O(n^2)$
B. $O(n)$
C. $O(n\log(n))$
D. $O(n^{\log(n)})$

Question 10

Which notion of computability was most important in developing recursion theory in computer science?

A. Halting problem
B. Church Turing thesis
C. Turing machines
D. Hilbert's program

Question 11

Which of these statements best describe why the pseudocode outlining the algorithm below is correct?

```
algorithm knapsack(i, W)
// Solves the knapsack problem
// Finds the highest number of points possible
// Input: i integer and W integer
// Output: Highest number of points possible
if (i < 0)
  return 0
if (weights[i] > W)
  return knapsack(i-1, W)
else
  return min(knapsack(i-1, W), knapsack(i-1, W - weights[i]) + values[i])
```

A. It halts
B. The boundary case is not correct
C. It finds the lowest sum of points rather than the highest
D. The algorithm is not correct

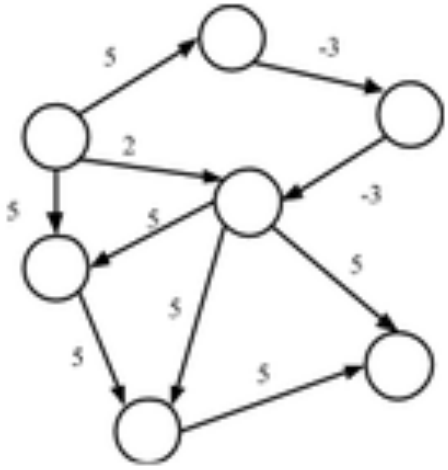
Question 12

In which scenario is black box testing preferable over white box testing?

A. Combining two different algorithms, fitting an output of one to match the input of the other.
B. The program tester is separate from the developer and is not subjected to bias
C. The programmer is able to see the underlying implementation of the algorithm.
D. The program is so large that to run it on a full scale would take years.

Question 13

Matthew devises an algorithm that finds a solution to a problem that he abstracted the inputs to a graph. He wants to find the shortest distance in a graph. Which algorithm is suited for his tasks, and what is the time complexity of that algorithm?



A. Bellman-Ford Algorithm (O(n^3))
B. Bellman-Ford Algorithm (O(n^4))
C. Floyd Algorithm (O(n^4))
D. Floyd Algorithm (O(n^3))

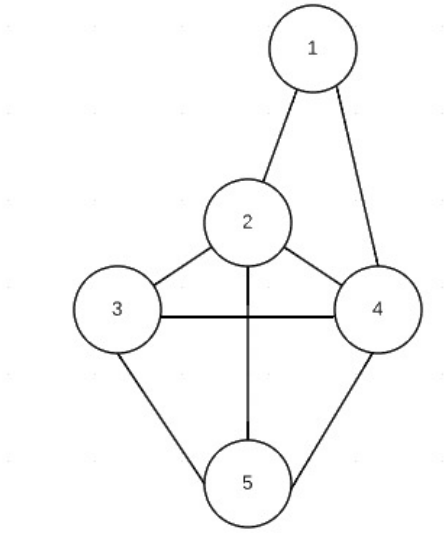
Question 14

How many non-reducible homeomorphic trees of degree 11 exist?

A. 14
B. 10
C. 6
D. 9

Question 15

How many spanning trees are in the graph below?



A. 10
B. 12
C. >15
D. There are none because the graph has cycles

Question 16

How many possible 3-wise testing cases exist with these inputs:

{1,2,3}
{A,B,C, D, E}
{34, 91, 32, 32}
{T,F}

A. 20
B. 60
C. 12
D. 120

Question 17

The Church Turing Thesis states that:

A. If a problem can described using axioms then it can be executed by a busy beaver.
B. If a problem can be solved using a Turing Machine then it is possible to determine if it will halt.
C. If a problem is algorithmically computable then it can be solved with at Turing Machine.
D. Artificial Intelligence is only possible if a computer can 'understand' what it is doing.

Question 18

Which set of four definitions is correct?

	A	**B**	**C**	**D**
Eulerian path	Visits all edges once	Visits all vertices once	Visits all edges once and starts and ends on the same vertex	Visits all vertices once and starts and ends on the same vertex
Eulerian circuit	Visits all edges once and starts and ends on the same vertex	Visits all vertices once and starts and ends on the same vertex	Same as eulerian path	Same as eulerian path
Hamiltonian path	Visits all vertices once	Visits all edges once	Visits all vertices once	Visits all edges once
Hamiltonian circuit	Visits all vertices once and starts and ends on the same vertex	Visits all edges once and starts and ends on the same vertex	Same as hamiltonian path	Same as hamiltonian path

Question 19

How do you convert an algorithm from recursive to iterative?

D. Use a loop invariant
E. First convert the algorithm into tail-recursive and then use a while or for loop to convert to iterative
F. It is sometimes never possible to do so
G. Delete the calls to the function and add a while or for loop

Question 20

What is the 2nd pivot chosen when performing quicksort on this array to do a descending sort:
'[4,3,6,9,1,2,7,5]'?
*Assume that pivot chosen is right most of the list

A. 3
B. 4
C. 7
D. 5

END OF SECTION A
TURN OVER

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided

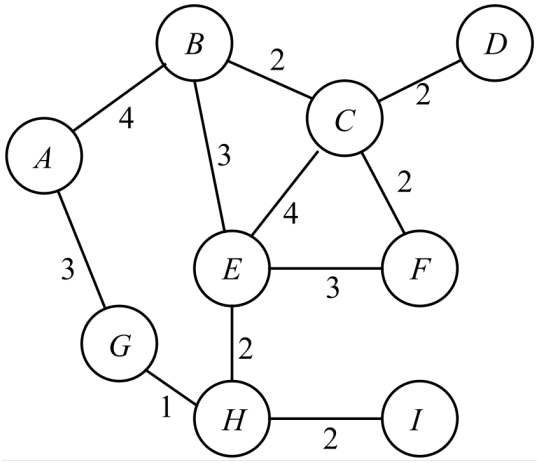
Question 1 (15 marks)

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

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

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

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

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

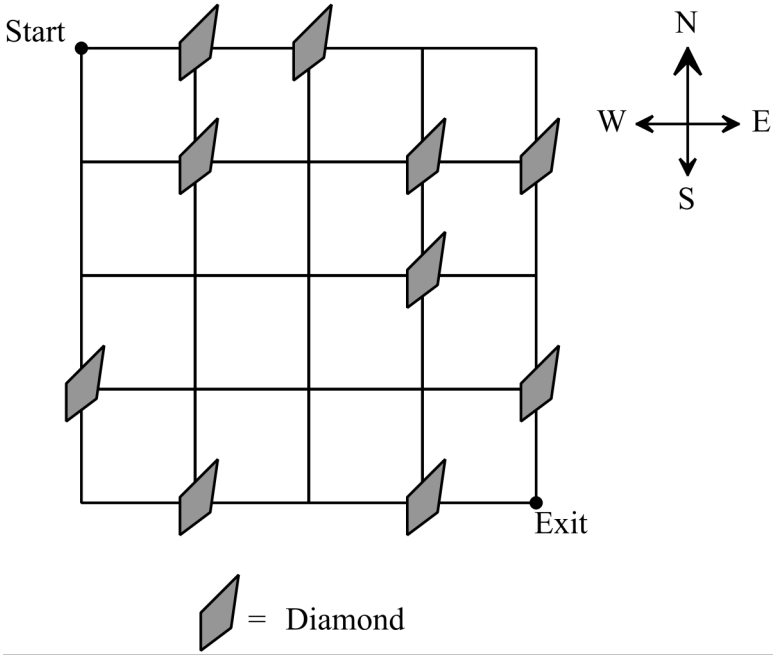
f. Explain which approach would be more appropriate for Bartholomew Highlander to use to find the shortest path to the diamond and justify your answer. 2 marks

"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

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

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

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*]

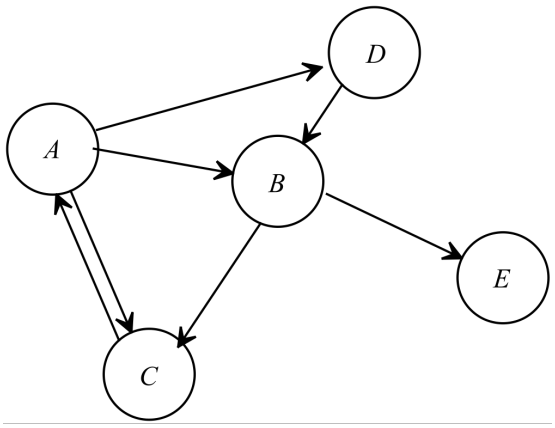
return F[*n* , *m*]

c. On the diagram below, assign the values assigned to each cell by the algorithm and identify a possible path that Bartholomew could follow to ensure that he obtains the maximum number of diamonds whilst making his escape. 2 marks

0				

Question 3 (8 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

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

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

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	

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

Question 6 (8 marks)

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

Question 7 (10 marks)

a. Outline John Searle's Chinese Room Argument and explain it's implications for computer science. 6 marks

b. Provide and explain two counter arguments to the Chinese Room Argument. 4 marks

Argument 1 - _____

Argument 2 - _____

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

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

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
```

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

Question 10 (8 marks)

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

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

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.

END OF QUESTION AND ANSWER BOOKLET