Zig Zag Education

Computer Science

A Level | OCR | H446

Topic Tests

for A Level OCR Computer Science

Component 2

zigzageducation.co.uk

POD 6354

Contents

Teacher's Introduction

This resource is designed to support teaching and learning of the A Level OCR specification (for first teaching in September 2015; first exams from June 2017).

These end-of-topic tests are designed as factual tests to check your students' understanding as they complete each topic*. Their primary focus is not to provide exam-style practice, but instead to test the knowledge, skills and understanding required by the OCR specification in a variety of styles and complexities – ranging from simple short-answer questions through to longer essay-style questions.

**The tests could also be used for homework or revision, but their best use is as summative assessments.*

The tests cover the prescribed specification content for *Component 1* of the A Level OCR specification – each provided in worksheet format (with answer lines) and a more photocopy-friendly format (without answer lines), to give you flexibility of use.

Each tests is worth between 30-40 marks, so that it can be comfortably completed within a single one-hour lesson. Example answers are provided for every test. *Note that credit should also be given for any valid responses that are not explicitly included in this resource.*

2.1.1–5 Computational Thinking 1

1. You have been tasked with developing a library that contains a single fun
array of floating-point values and returns a new array containing the sam
ascending order.

   a) Identify the information about the input array that `fsort` would req

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   b) Explain the benefits of placing `fsort` in a library rather than direct

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   c) A platform that the library will be used on contains a processor with
for sorting floating-point numbers. Give two ways you could make a
instruction on this platform. Which method would you recommend a

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2. A programmer has a problem. They want to log debug information to eit
depending on an option the user has set. This has led to their code conta
code repeatedly:

```
msg = "..."
if options.getPrintToScreen() then
   print(msg)
elseif options.getPrintT...() then
   options.getFile(...)(msg)
endif
```

   a) Pr... a way of reducing the amount of repetition in their code.

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Questions continue on the following page

b) Explain how your proposal would make it easier to add new features adding a timestamp as a prefix to each message.

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3. Consider the following design brief for a new cont[illegible]s ticketing system

'The customer will walk up to the scree[illegible] the cinema that is showing the [illegible] screen there will be a barrier, a touchscreen display, a receipt printer and a payment card on. The customer will use the touchscreen to select the numb[illegible] want to buy. The customer will then tap their contactless card on the pad. If will ap[illegible]king them to go to reception. If the payment succeeds a mess[illegible] the entrance to the screen telling it to let in the number of people tickets ha[illegible] also print a receipt.'

a) Identify all the inputs of the ticketing system described.

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b) Identify all the outputs of the ticketing system described.

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c) Draw a flow chart representing the process described.

d) Convert the process shown in the flow chart into pseudocode.

4. A dictionary consists of a list of all the words in the English language.

a) Assume the dictionary is held in a linked list.

i. Describe in words an algorithm that checks if a given word is in

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ii. What is the worst-case time complexity of the algorithm describ

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iii. Suppose you have access to multiple processors. Describe how t
to run on more than one processor at on

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iv. Will spreading the algorithm across multiple processors reduce
complexity of the algorithm? Explain your answer.

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b) Propose a data structure that the dictionary could be stored in that v
looked up in O(1) time.

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c) The new data structure is too large to be held in main memory and s
Assume that a small set of words is likely to be checked much more
you do not know these words in advance.

Describe a strategy that could be used to reduce the time to look up
Explain any drawbacks your approach has.

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2.1.1–5 Computational Thinking 2

1. Imagine you have been put in charge of developing an application that w
room in the event of a fire.

   a) A model is an example of an abstraction. Explain what an abstraction
   context.

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   b) Identify four inputs that your model would need in order to calculate
   could be evacuat

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   c) Explain why the speed of a real evacuation might differ from the spe
   application.

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Questions continue on the following page

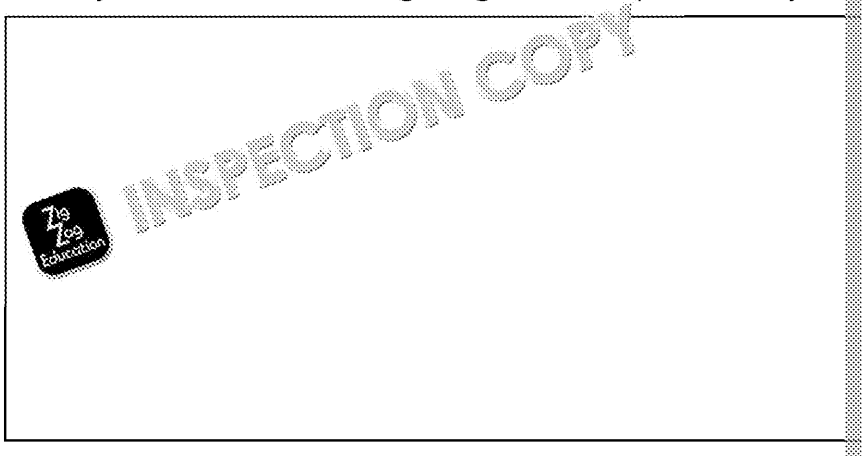
2. While reading ASCII-encoded text from a network you run into the proble
wrong order. The order of every group of four bytes is reversed. So, for e

```
TRANSMITTED OVER THE NETWORK
```

would be read as:

```
NARTTIMS DETREVOEHT TEN KROW
```

a) Use pseudocode to write a procedure that unscrambles a complete m
You may assume that the message length is a multiple of four bytes.



b) There are a number of different applications that need to receive dat
you could share the procedure you have written between them.

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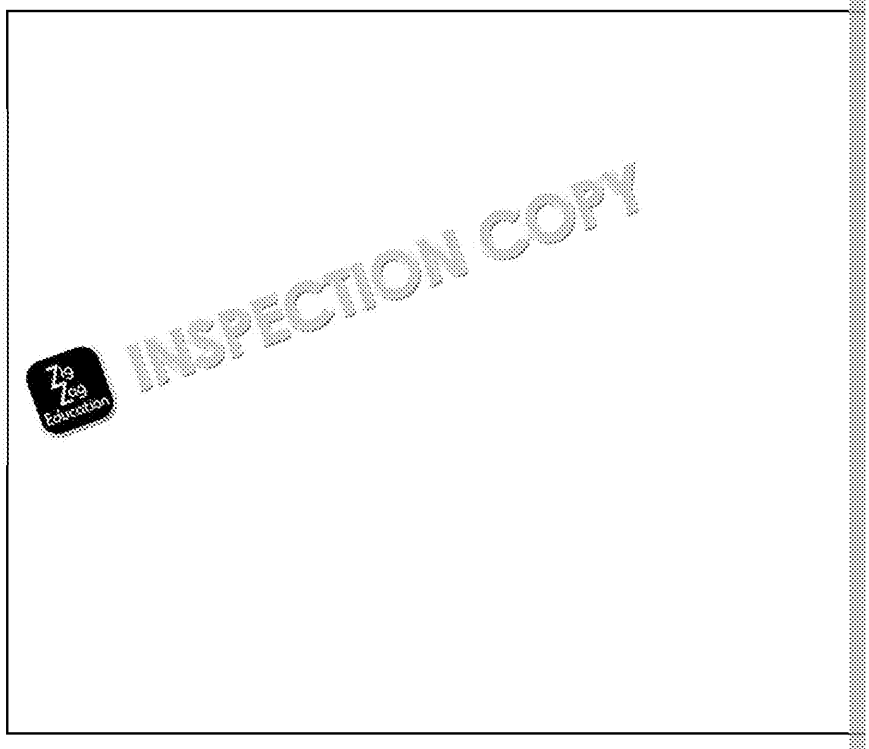
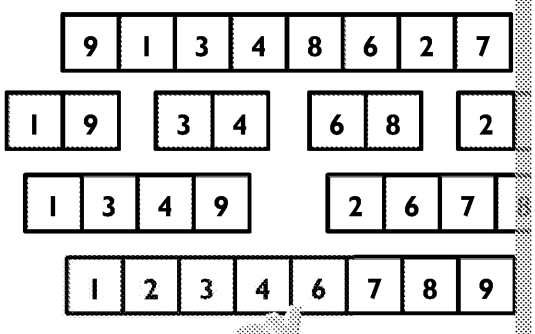
c) Data that is sent over the network can be compressed. The bytes are
order. Use the procedure you wrote in part (a) to write a procedure t
decompresses a message. You may use the procedure `decompress`
message.



3. The following diagram represents the steps required to sort an array of e algorithm:



The algorithm works by first splitting the array into pairs, sorting each inc to create two arrays of four elements, and then finally merging the create a final array of sorted values.

a) Identify the parts of this algorithm that can be executed concurrently executed sequentially.

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b) Use your answer to part (a) to calculate the maximum theoretical spe each step of this algorithm given an infinite number of processors.

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c) Explain two reasons why it may not be possible to achieve the speed

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4. People have difficulty reading text on a website can make use of spe selected words on the screen aloud to them.

a) Identify the inputs and outputs of screen-reading software.

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b) It can be difficult for people who have difficulty seeing things on scre
website that they are interested in to be read out. Describe an appro
to overcome this problem.

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c) Converting [illegible] into speech is computationally intensive. Describe
b[illegible] to speed up the conversion of a large amount of text.

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2.2.1 Programming Techniques

1. Consider the following pseudocode:

```
var noOfTurns = input("Enter the number of turns: ")
if noOfTurns < 1 then
    print("Error - must be at least 1")
else
    for x=1 to noOfTurns
        print(x)
        ...
    next x
endif
```

B

C

Here is a list of statement types that can be used in programming langua

- ...le declaration
- Assignment
- Constant declaration
- Iteration

Identify the statement that best suits parts A, B and C of the pseudocode

A .....

B .....

C .....

2. a) Explain the difference between a constant and a variable.

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b) Explain the difference between a global variable and a local variable.

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c) Explain how parameters can be used to avoid the use of global varia

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d) A colleague has decided that when they are programming they are g in the order they are used, i.e. x1, x2, x3, x4... and so on. What is the p would you recommend they do instead?

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3. Programmers often use IDEs to improve their productivity.

   a) What does IDE stand for?

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   b) IDEs often contain an auto-completion feature. Explain what an auto
   how it can improve the productivity of a programmer.

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   c) A debugger can help a pro[illegible]mmer debug their project.

   i. Explain the use of a breakpoint in a debugger.

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   ii. Explain why compiler optimisations might have to be disabled t

   .....

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4. The factorial of a number ($n!$) is defined as:

$$n! = \begin{cases} 1 & if\ n = 0 \\ n \times (n-1)!\ if\ n > 0 \end{cases}$$

   For example:

$$6! = 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 720$$

   a) Write an iterative function called *factorial* that calculates the factoria
   returns the answer.

   b) Rewrite the function *factorial* without using a loop.

c) What is the name of the programming technique you have employe

.....

d) Which of the functions in parts (a) and (b) is likely to calculate the fac
Explain your answer.

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5. The object-oriented programming lan[illegible] Java can represent integers i
primitive type `int` or as an inst[illegible] of the `Integer` class.

a) Primitive types in Java are passed by value whereas objects are passe
di[illegible]ce between passing arguments by value and by reference.

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b) Does `Integer` inherit from `int` or does it encapsulate an `int`? Expl

.....

.....

c) You are given the following class representing a character in a fantas

```
class Character
    hitPoints
    procedure attack(enemy) // enemy is also a Ch
        ...
    endprocedure
    ...
endclass
```

A common enemy in the game is a goblin. Goblins are clumsy creatu
themselves when attacking.

i. Give an advantage of having all the characters in the game inherit f

.....

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ii [illegible]lai[illegible]ow polymorphism can be used to allow goblins to dam
[illegible]cking.

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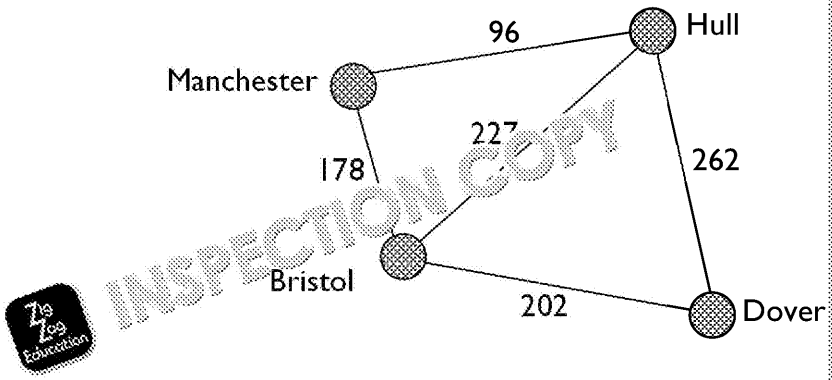
Preview of Questions Ends Here

2.2.2 Computational Methods

A calculator is recommended for this test.

1. The travelling salesman problem involves finding the shortest route betw each city is visited once and only once. The problem can be visualised usi following:

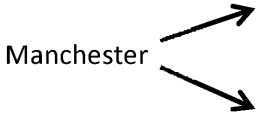


a) The graph in this question is an example of an abstraction. What is a useful?

b) The travelling salesman problem is an example of an intractable prob

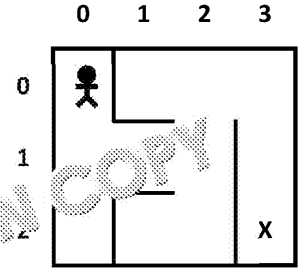
i. What is an intractable problem?
ii. What approach can be used to reduce the time needed to solve Will the result of using this approach be the same as the result o

c) Fill in the following tree diagram to represent every solution to the p start city is fixed at Manchester.



d) Use the diagram to calculate the optimal distance in this case.

2. Consider the following 4x3 maze:



The pe[illegible] the maze in square (0, 0). They can then move one s unless s a wall in their way. They can only see the walls in the squar they can record information about squares they have seen already.

For example, square (0, 0) has three walls, leaving the only direction the p Once in the square (0, 1) the person only has a wall on the left, so they ca the purposes of this question you may assume that the maze does not co cannot walk through the square twice unless they retrace their steps).

The goal of the person in the maze is to find the treasure, marked with an location in advance.

a) Describe in words how the person would know they had hit a dead e

b) Describe in words how *backtracking* could be used by the person to

c) Use the language of your choice to define a record or class that cont
about a visited square that an algorithm based on backtracking wou

d) Identify the most suitable data structure to use to hold instances of t
defined in part (c) in an iterative procedure that implements an algor
backtracking. Explain your answer.

3. You are tasked with finding all the multiples of a given positive integer in
integers. For example, given the number 3 and the array [3, 4, 8, 9, 12, 13
return the list [3, 9, 12, 18].

a) Write a pseudocode function that finds the multiples by iterating thr
each number in turn.

b) It takes 0.1 ms to load a number from main memory. Assuming that
no other time, calculate approximately how long it will take to searc
1,048,576 numbers to the nearest second.

c) The number you are given will be large and there will most likely be
between each multiple you find. Give the name of a technique that c
multiples in less time when this is the case.

d) Write a pseudocode function that uses the technique given in part (c

e) Calculate the approximate amount of time that the algorithm you ha
all the multiples in an array in the worst case to the nearest second.

You may assume the following information is true:

- There are 1,048,576 numbers in the array.
- The number you are given to search for is 10,748 and the la
32,244,000.
- It takes 0.1 ms to load a number from main memory, and o
negligible time.

2.3.1 Algorithms 1 (complexity and sorting)

1. The table below contains a list of orders of time complexity (in no particu

Order of time complexity
O(1)
$O(n^2)$
O(log n)
O(n)

a) Match the time complexities in the table to the worst-case time com operations:

i. A binary s...
ii. ...dding the first item in a linked list
iii. ...ear search
iv. An insertion sort

b) Convert the following runtimes into Big O notation:

i. $n^3 + 4n^2$
ii. $128n + 4 \log n$
iii. $9^n - 17n^5$
iv. 128

c) Explain the difference between *time* and *space* complexity.

2. Consider the following array of unsorted values:

12	10	7	1	4	22	3	5

a) Sort this array using the merge sort algorithm. Show the output of e

b) What is the time complexity of the merge sort algorithm?

c) Can a merge sort be done in-place? Explain your answer.

3. Consider the following array of sorted values:

3	8	12	16	18	21		
						Empty slots	

a) Give the worst-case space complexity of an insertion sort.

b) Describe how the value 7 would be inserted into this array using ins

c) E... the reasons why insertion sort is more appropriate than merg... va... a sorted array and re-sorting.

4. Consider the following algorithm:

```
procedure Sort( A : list of sortable items )
  do
    swapped = false
    for each i in 1 to length(A) - 1 inclusive do
      if A[i-1] > A[i] then
        Temp = A[i-1]
        A[i-1] = A[i]
        A[i] = Temp
        swapped = true
      end if
    end for
  while swapped
end procedure
```

a) What type is sort is being carried out with this algorithm?

b) Describe how the sort technique works.

c) Using the following data, construct a trace table for this sort algorithm:

height	
1	90
2	7
3	99
4	63

Use the following format:

Swapped	Count	Length(A)	Temp	height	
				1	2
False		4	null	90	7

d) State the completed answer for part c.

5. Consider the following array of unsorted values:

1	8	4	3	7	2	6	5	9

Quicksort is a sorting algorithm invented by Tony Hoare in 1959.

a) What is the best number in this array to choose as the first pivot point?

b) The worst-case time complexity of quicksort is the same as bubble sort, so why is it considered a faster sorting algorithm than bubble sort.

2.3.1 Algorithms 2 (search)

1. Consider this array:

Index	1	2	3	4	5	6	7
Data	14	18	19	22	23	25	24

   a) Why can't a binary search be performed on this array in its current st

   b) Fix the array so that a binary search can be performed. Perform a bin
   24. Explain each step of the algorithm.

   c) Give the worst-case time complexity of th[illegible]y search algorithm o

   d) Would the worst-case time co[illegible]ty of the binary-search algorithm
   used instead of an arra[illegible] your answer.

   e) In the worst [illegible]ould it be faster to do a linear search on the origi
   d[illegible]ar search? Explain your answer.

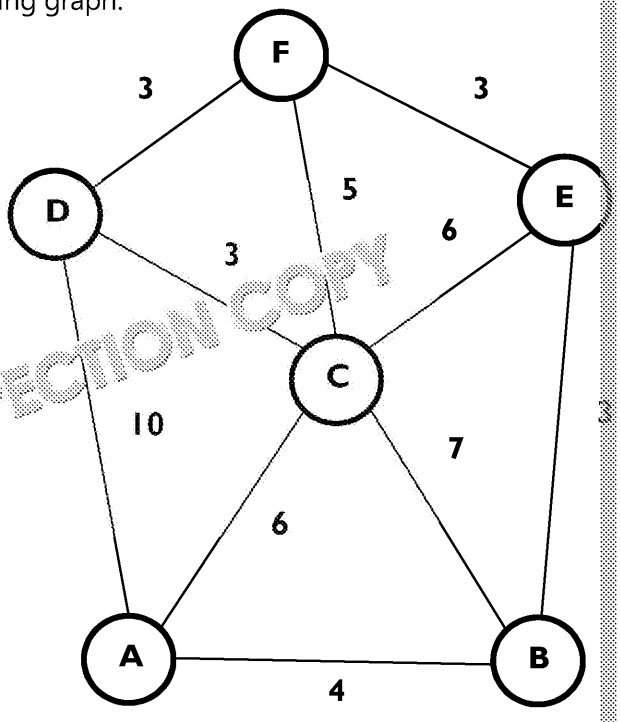
2. Consider the following algorithm:

```
function ShortestPaths(graph, start)
    unvisited = new set()
    distances = new map()
    previous  = new map()

    distances[start] = 0
    previous[start]  = nil

    for each vertex in graph
        unvisited.add(vertex)
        if vertex != start
            distances[vertex] = infinity
            previous[vertex]  = nil
        endif
    next vertex

    while unvisited.size() > 0
        min_distance = infinity
        candidate    = nil

        for each vertex in graph
            if unvisited.contains(vertex) and dista
min_distance
                candidate    = vertex
                min_distance = dista[illegible]es[vertex]
            endif
        next vertex

        for each [illegible]dge in candidate.neighbours()
            [illegible] edge.destination()
            unvisited.contains(vertex)
                if min_distance + edge.length() < d
                    distances[vertex] = min_distan
                    previous[vertex]  = candidate
                endif
            endif
        next edge

        unvisited.remove(candidate)
    endwhile

    return distances, previous
endfunction
```

a) What is the name of the algorithm shown above?

b) What is the worst-case time complexity of this algorithm (you may a
operation are O(1))?

c) Consider the following graph:



i. Trace the order in which the vertices would be removed from th
algorithm when finding the shortest paths from A.

ii. Copy and complete the following tables so that they reflect the
and `previous` variables following the execution of the algorith

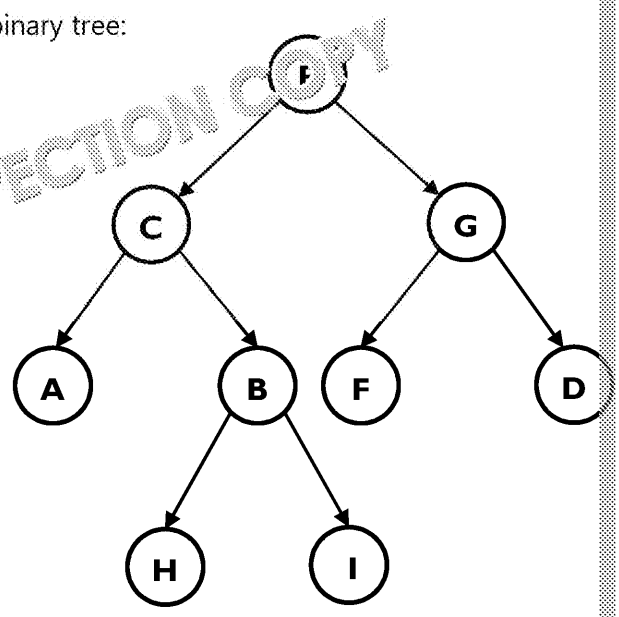
distances	A	B	C	D

previous	A	B	C	D

iii. What is the route of the shortest path between A and F?

iv. What is the length of the shortest path between A and F?

3. Consider the following binary tree:



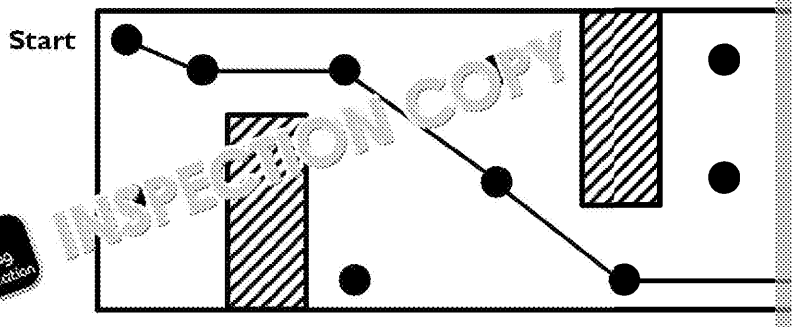
The data that each node contains is the ASCII character code of the label

a) Is this tree a binary search tree? Explain your answer.

b) Complete a breadth-first traversal of the tree.

c) Complete a depth-first pre-order traversal of the tree.

4. For an electronics project you are working on you need to find the shorte piece of board between two points. Inserted into the board are nails that around in order to change its direction to route the wire around obstacle



a) Identify a suitable data structure to use to represent this problem.

b) Describe a heuristic that could be used to reduce the time it takes to between the two points.

c) Give the name of an algorithm that could be used to find the shortes heuristic you have identified.

d) What property must your heuristic have in order to use the algorithm

e) Does the algorithm you have identified always find the shortest poss answer.

Preview of Answers Ends Here