Paper Reference 9FM0/3D
Pearson Edexcel Level 3 GCE

Further Mathematics

Advanced

Paper 3D: Decision Mathematics 1

Monday 24 June 2019 – Morning

Time: 1 hour 30 minutes plus your additional time allowance.

MATERIALS REQUIRED FOR EXAMINATION
Mathematical Formulae and Statistical Tables (Green), calculator

ITEMS INCLUDED WITH QUESTION PAPERS
Diagram Book
Answer Book

X61182A

Pearson

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

INSTRUCTIONS

Write your answers for this paper in the Answer Book provided.

In the boxes on the Answer Book and on the Diagram Book, write your name, centre number and candidate number.

Do NOT return the Question Paper with the Answer Book.

Answer ALL questions and ensure that your answers to parts of questions are clearly labelled.

Answer the questions in the Answer Book or on the separate diagrams – there may be more space than you need.

Do NOT write on the Question Paper.

You should show sufficient working to make your methods clear. Answers without working may not gain full credit.

Answers should be given to three significant figures unless otherwise stated.

INFORMATION

A booklet 'Mathematical Formulae and Statistical Tables' is provided.

There are 7 questions in this Question Paper.

The total mark for this paper is 75

The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.

ADVICE

Read each question carefully before you start to answer it.

Try to answer every question.

Check your answers if you have time at the end.

Answer ALL questions.

Write your answers in the Answer Book or on the diagrams for this paper.

1.

2·1	1·7	3·0	1·9	3·2
1·2	3·3	1·4	1·5	0·2

(a) Use the first–fit bin packing algorithm to determine how the numbers listed above can be packed into bins of size 5
(2 marks)

The list of numbers is now to be sorted into descending order.

(b) Perform a quick sort on the original list to obtain the sorted list.
You should show the result of each pass and identify your pivots clearly.
(4 marks)

(continued on the next page)

1. continued.

For a list of n numbers, the quick sort algorithm has, on average, order $n \log n$

Given that it takes $2 \cdot 32$ seconds to run the algorithm when $n = 450$

(c) calculate approximately how long it will take, to the nearest tenth of a second, to run the algorithm when $n = 11\,250$

You should make your method and working clear.

(2 marks)

(Total for Question 1 is 8 marks)

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2. Refer to Diagram 1 and Diagram 2 in the Diagram Book.

Diagram 1 represents a network of corridors in a building.
[The total weight of the network is 370]
The number on each arc represents the length, in metres, of the corresponding corridor.

(a) Use Dijkstra's algorithm to find the shortest path from A to D, stating the path and its length.
(See Diagram 2)
(6 marks)

(continued on the next page)

2. continued.

On a particular day, Naasir needs to check the paintwork along each corridor.

Naasir must find a route of minimum length.

It must traverse each corridor at least once, starting at B and finishing at G

(b) Use an appropriate algorithm to find the arcs that will need to be traversed twice.

You must make your method and working clear.

(4 marks)

(c) Find the length of Naasir's route.

(1 mark)

(continued on the next page)

2. continued.

On a different day, all the corridors that start or finish at **B** are closed for redecorating.

Naasir needs to check all the remaining corridors and may now start at any vertex and finish at any vertex.

A route is required that excludes all those corridors that start or finish at **B**

(d) (i) Determine the possible starting and finishing points so that the length of Naasir's route is minimised.

You must give reasons for your answer.

(ii) Find the length of Naasir's new route.

(3 marks)

(Total for Question 2 is 14 marks)

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3. Refer to Diagram 3, Diagram 4, Diagram 5 and Diagram 6 in the Diagram Book.

The network in Diagram 3 shows the direct roads linking five villages, **A**, **B**, **C**, **D** and **E**
The number on each arc represents the length, in miles, of the corresponding road.
The roads from **A** to **E** and from **C** to **B** are one–way, as indicated by the arrows.

(a) Complete the initial distance and route tables for the network provided in Diagram 4 in the Diagram Book.
(2 marks)

(b) Perform the first three iterations of Floyd's algorithm.
You should show the distance table and the route table after each of the three iterations.
(See Diagram 5)
(5 marks)

(continued on the next page)

3. continued.

After five iterations of Floyd's algorithm the final distance table and partially completed final route table are shown in Diagram 6 in the Diagram Book.

(c) (i) Explain how the partially completed final route table can be used to find the shortest route from E to A

(ii) State this route.

(3 marks)

(continued on the next page)

3. continued.

Mabintou decides to use the distance table to try to find the shortest cycle that passes through each vertex.

Starting at D, she applies the nearest neighbour algorithm to the final distance table.

(d) (i) State the cycle obtained using the nearest neighbour algorithm.

(ii) State the length of this cycle.

(iii) Interpret the cycle in terms of the actual villages visited.

(iv) Prove that Mabintou's cycle is not optimal.

(4 marks)

(Total for Question 3 is 14 marks)

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4. Refer to Diagram 7 and Diagram 8 in the Diagram Book.

The network in Diagram 7 shows the activities that need to be undertaken to complete a project.
Each activity is represented by an arc and the duration of the activity, in days, is shown in brackets.
The early event times and late event times are to be shown at each vertex and one late event time has been completed for you.

The total float of activity H is 7 days.

(a) Explain, with detailed reasoning, why $x = 11$
(2 marks)

(b) Determine the missing early event times and late event times, and hence complete Diagram 7 in the Diagram Book.
(3 marks)

(continued on the next page)

4. continued.

Each activity requires one worker and the project must be completed in the shortest possible time using as few workers as possible.

(c) Calculate a lower bound for the number of workers needed to complete the project in the shortest possible time.

(1 mark)

(d) Schedule the activities using Diagram 8 in the Diagram Book.

(3 marks)

(Total for Question 4 is 9 marks)

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5. Refer to Diagram 9 in the Diagram Book.

It shows a precedence table.

(a) Draw the activity network described in the precedence table, using activity on arc.
Your activity network must contain only the minimum number of dummies.
(5 marks)

Given that all the activities shown in the precedence table have the same duration,

(b) state the critical path for the network.
(1 mark)

(Total for Question 5 is 6 marks)

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6. Refer to Diagram 10 and Diagram 11 in the Diagram Book.

A linear programming problem in x, y and z is described as follows.

Maximise

$$P = 2x + 2y - z$$

subject to

$$3x + y + 2z \leq 30$$

$$x - y + z \geq 8$$

$$4y + 2z \geq 15$$

$$x, y, z \geq 0$$

(a) Explain why the Simplex algorithm cannot be used to solve this linear programming problem. (1 mark)

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6. continued.

(b) Set up the initial tableau for solving this linear programming problem using the big–M method. (see Diagram 10)
(7 marks)

After a first iteration of the big–M method, the tableau is shown in Diagram 11

(c) State the value of each variable after the first iteration.
(1 mark)

(d) Explain why the solution given by the first iteration is not feasible.
(1 mark)

Taking the most negative entry in the profit row to indicate the pivot column,

(e) obtain the most efficient pivot for a second iteration.
You must give reasons for your answer.
(2 marks)

(Total for Question 6 is 12 marks)

7. Refer to Diagram 12 in the Diagram Book.

A shop sells two types of watch, analogue watches and digital watches.

The shop manager knows that, each month, she should order at least 60 watches in total.
In addition, at most 80% of the watches she orders must be digital.

Let x be the number of analogue watches ordered and let y be the number of digital watches ordered.

(a) Write down inequalities, in terms of x and y, to model these constraints.
(2 marks)

(continued on the next page)

7. continued.

Two further constraints are

$$y + 3x \geq 140$$

$$4y + x \geq 80$$

(b) Represent all these constraints on Diagram 12 in the Diagram Book.
Hence determine, and label, the feasible region, **R**
(4 marks)

The cost to the shop of ordering an analogue watch is five times the cost of ordering a digital watch.
The shop manager wishes to minimise the total cost.

(c) Determine the number of each type of watch the shop manager should order.
You must make your method clear.
(3 marks)

(continued on the next page)

7. continued.

Given that the minimum total cost of ordering the watches is £4455

(d) determine the cost of ordering one analogue watch and the cost of ordering one digital watch. You must make your method clear.

(3 marks)

(Total for Question 7 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS

END OF PAPER
