Pearson Edexcel Level 3 GCE

Specimen Paper

(Time: 1 hour 30 minutes) | Paper Reference **9FM0/3D**

Further Mathematics

Advanced

Paper 3D: Decision Mathematics 1

You must have:
Decision Mathematics Answer Book (enclosed), calculator

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

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- Write your answers for this paper in the Decision Mathematics answer book provided.
- **Fill in the boxes** at the top of the answer book with 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 spaces provided
  – *there may be more space than you need.*
- 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.

Turn over ▶

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Answer ALL questions. Write your answers in the answer book provided.

1. 6 1 9 14 18 7 10 4 17 13

(a) The list of numbers shown above is to be sorted into descending order. Apply the quick sort algorithm to obtain the sorted list. You must make your pivots clear.

(3)

(b) Apply the first-fit decreasing bin packing algorithm to your ordered list to pack the numbers into bins of size 30

(2)

(Total for Question 1 is 5 marks)

2.

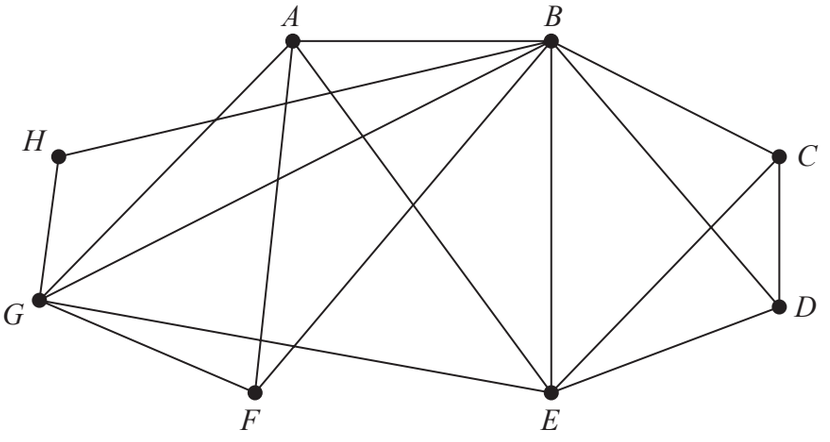

Figure 1

(a) Write down the number of arcs in a minimum spanning tree for the graph shown in Figure 1.

(1)

(b) Determine the minimum number of arcs that would need to be added to make the graph semi-Eulerian. You must justify your answer.

(2)

Taking AFGHBCDEA as the Hamiltonian cycle,

(c) use the planarity algorithm to determine whether or not the graph shown in Figure 1 is planar. You must make your working clear and justify your answer.

(3)

(Total for Question 2 is 6 marks)

3.

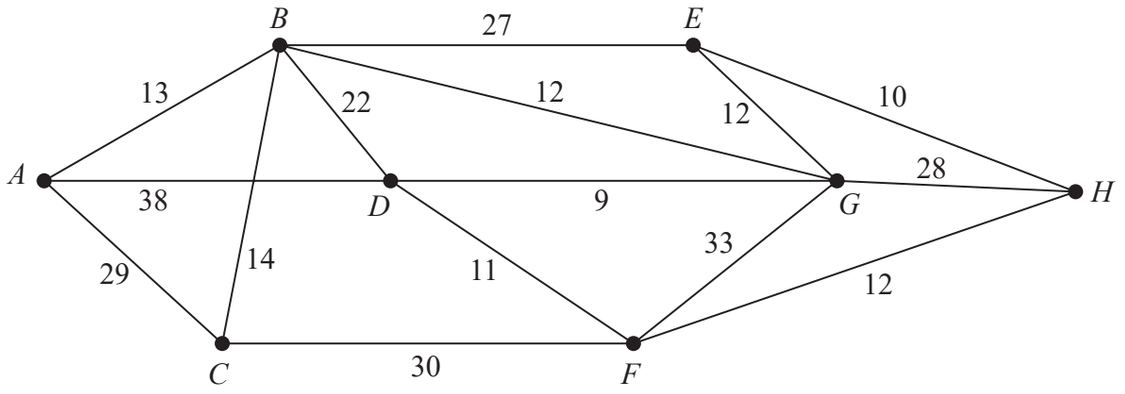

Figure 2

[*The total weight of the network is 300*]

Figure 2 represents a network of train tracks. The vertices A, B, C, D, E, F, G and H represent train stations.

(i) The number on each edge represents the time, in minutes, to travel on the corresponding track.

(a) Use Dijkstra's algorithm to find the time required to travel the quickest route from A to H.

(4)

A train is to travel from A to F via H without stopping.

(b) Find the quickest route from A to F via H. State the route and the time taken.

(2)

A train is to travel from A to H, stopping for 1 minute at each train station it passes through on its route.

(c) Explain how you would adapt the network so that Dijkstra's algorithm could be used to find the quickest route for this train. You do not need to find this route.

(2)

(ii) The number on each edge **now** represent the length, in km, of the corresponding track. A route that starts at C, finishes at G and traverses each track at least once needs to be found.

(a) Use an appropriate algorithm to find the length of the shortest route. You must make your method clear.

(4)

(b) State the tracks that will need to be traversed twice.

(1)

(Total for Question 3 is 13 marks)

4. The table below lists the durations (in minutes), the immediate preceding activities and the number of workers required for each activity in a project.

Activity	Duration (minutes)	Immediate preceding activities	Number of workers
A	20	-	1
B	15	-	1
C	35	-	2
D	10	C	1
E	35	A	1
F	20	A	2
G	10	A, B, D	1
H	25	C	1
I	30	E	1
J	20	E, F, G, H	2

The project is modelled by the activity network shown in Figure 3. The activities are represented by the arcs. The project is to be completed in the shortest possible time.

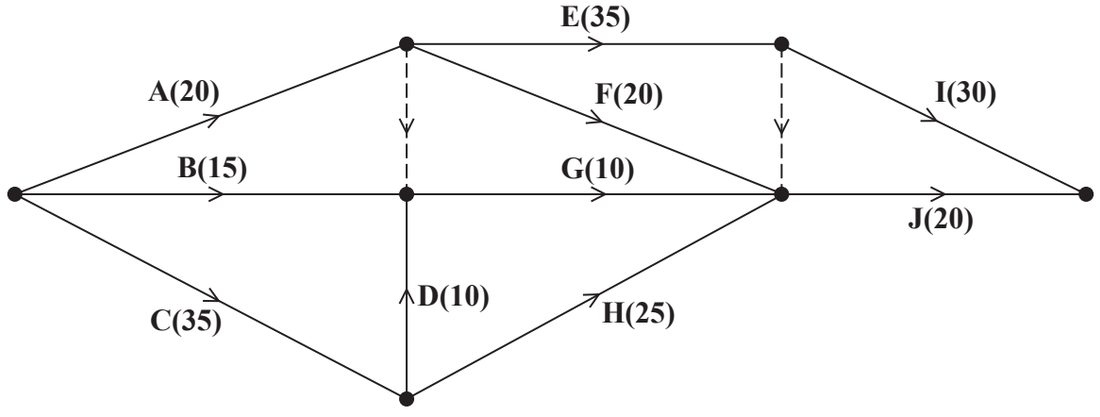

Figure 3

(a) (i) Calculate the early time and the late time for each event, using Diagram 1 in the answer book.

(ii) Determine the minimum project completion time.

(iii) Identify the critical activities.

(5)

(b) On Grid 1 in the answer book, draw a resource histogram to show the number of workers required at each time when each activity begins at its earliest possible start time.

(3)

(c) Determine whether or not the project can be completed in the minimum possible time by at most four workers. You must justify your answer with reference to your resource histogram.

(2)

(Total for Question 4 is 10 marks)

5. Dale is planning a production run of three types of desk. The three types are lectern desk, roll top desk and writing desk.

In total, Dale has 400 m^2 of wood available; each lectern desk requires 3 m^2, each roll top desk requires 5 m^2, and each writing desk requires 8 m^2

In total, Dale has 350 hours available; each lectern desk requires 3 hours, each roll top desk requires 6 hours, and each writing desk requires 10 hours.

Once complete, the desks need to be stored in a warehouse. The warehouse has 75 m^3 of storage space available; each lectern desk requires 1 m^3, each roll top desk requires 1.5 m^3 and each writing desk requires 1.25 m^3

The profit on each lectern desk sold is £40, the profit on each roll top desk sold is £50 and the profit on each writing desk sold is £65

Dale wants to maximise his profit.

Let x, y and z be the number of lectern desks, roll top desks and writing desks made respectively during the production run.

(a) Formulate this situation as a linear programming problem, giving your constraints as inequalities.

(4)

(b) Complete the initial tableau in the answer book for this linear programming problem.

(2)

(c) Taking the most negative number in the profit row to indicate the pivot column, perform one complete iteration of the Simplex algorithm. Give an explanation of the method by clearly stating the row operations you use.

(4)

After a second iteration, the exact values in the tableau are

b.v.	x	y	z	s_1	s_2	s_3	Value
s_1	0	−0.52	0	1	−0.68	−0.96	90
z	0	0.24	1	0	0.16	−0.48	20
x	1	1.2	0	0	−0.2	1.6	50
P	0	13.6	0	0	2.4	32.8	3300

(d) Use algebra to explain how you know that this tableau is optimal.

(1)

(e) (i) State the optimal number of each type of desk that should be made.

(ii) State the maximum total profit.

(2)

(f) Explain, in context, the meaning of the 90 in the value column.

(2)

(g) Give a reason why the profit may be less than the value stated in (e)(ii).

(1)

(Total for Question 5 is 16 marks)

6.

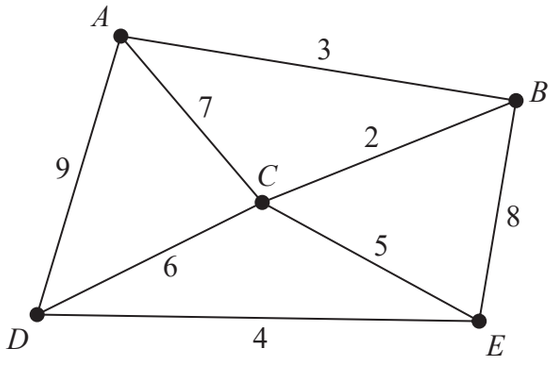

Figure 4

The network in Figure 4 shows the direct routes linking five towns, A, B, C, D and E. The edge weights represent distances, in km, between the towns.

(a) For this network, complete the initial distance and route tables provided in the answer book.

(2)

(b) Perform the first and second iterations of Floyd's algorithm. You should show the distance table and the route table after each iteration.

(4)

The final tables after five iterations of Floyd's algorithm are shown below.

Distance table

	A	**B**	**C**	**D**	**E**
A	–	3	5	9	10
B	3	–	2	8	7
C	5	2	–	6	5
D	9	8	6	–	4
E	10	7	5	4	–

Route table

	A	**B**	**C**	**D**	**E**
A	A	B	B	D	C
B	A	B	C	C	C
C	B	B	C	D	E
D	A	C	C	D	E
E	C	C	C	D	E

(c) Draw the complete network of shortest distances.

(2)

(d) (i) Use the nearest neighbour algorithm, starting at vertex E, to produce a Hamiltonian cycle for the complete network.

(ii) Write down the length of the Hamiltonian cycle.

(2)

(e) Interpret the Hamiltonian cycle from (d) in terms of the towns actually visited.

(1)

(f) Starting by deleting A from the complete network of shortest distances, and all of its edges, find a lower bound for the solution to the Travelling Salesman problem.

(2)

(g) Use your results to write down the smallest interval that you can be confident contains the optimal solution to the Travelling Salesman problem.

(2)

(Total for Question 6 is 15 marks)

7.

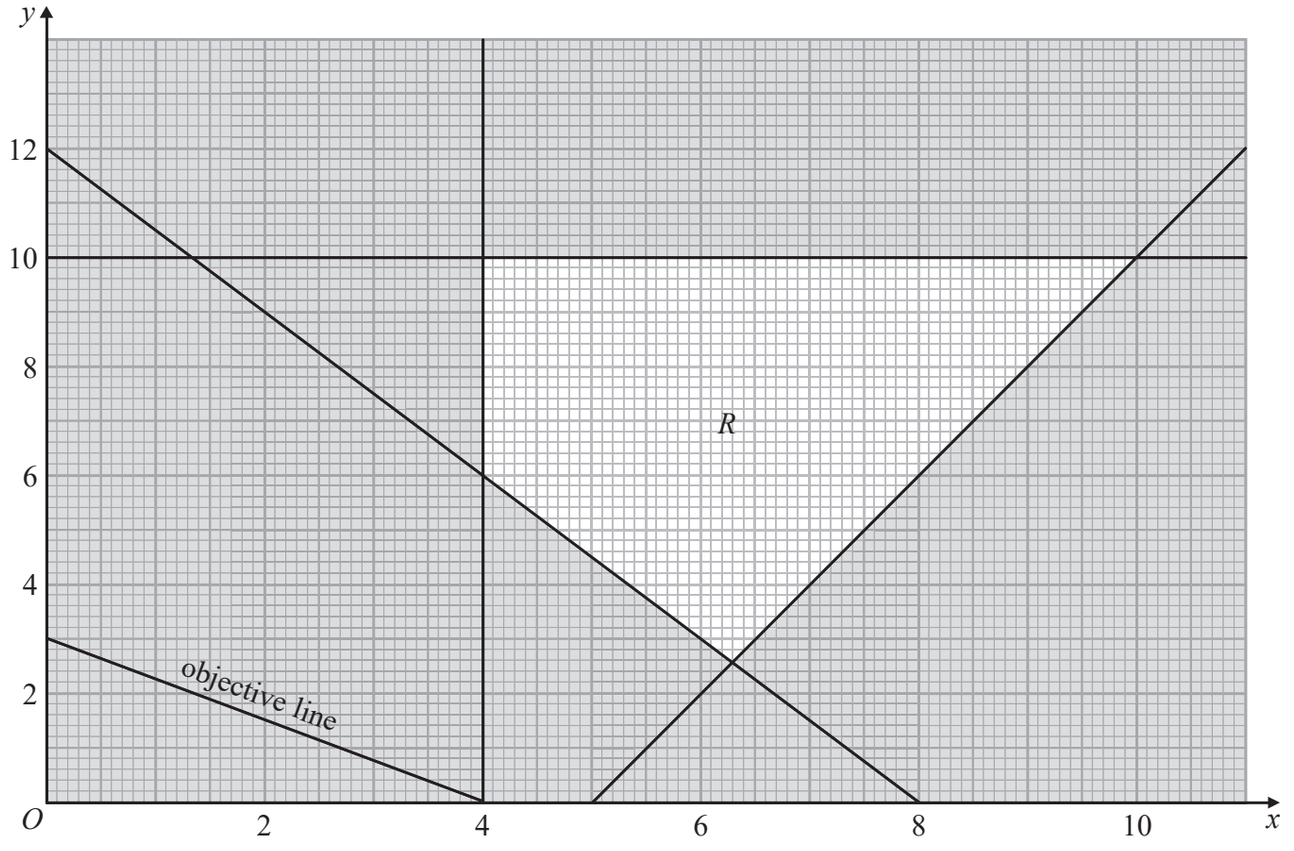

Figure 5

Figure 5 shows the constraints of a maximisation linear programming problem in x and y, where R is the feasible region. An objective line is also shown and labelled on Figure 5.

A student decides to find the optimal vertex of R by using the two-stage Simplex algorithm.

Set up an initial tableau for the two-stage Simplex algorithm. (You should not solve the linear programming problem.)

(Total for Question 7 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS