Pearson
Edexcel GCE

Decision Mathematics D2

Advanced/Advanced Subsidiary

Friday 23 June 2017 – Morning
Time: 1 hour 30 minutes

Paper Reference
6690/01

You must have:
D2 Answer Book

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra 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). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** on the top of the answer book with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the D2 answer book 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.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.
- Do not return the question paper with the answer book.

Information

- 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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P 4 9 1 1 2 A

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Write your answers in the D2 answer book for this paper.

1.

	A	B	C	D	E	F
A	–	83	75	82	69	97
B	83	–	94	103	77	109
C	75	94	–	97	120	115
D	82	103	97	–	105	125
E	69	77	120	105	–	88
F	97	109	115	125	88	–

The table above shows the least distances, in km, between six towns, A, B, C, D, E and F.

(a) Starting at A, and making your working clear, find an initial upper bound for the travelling salesperson problem for this network, using

(i) the minimum spanning tree method,

(ii) the nearest neighbour algorithm.

(5)

By deleting A, and all of its arcs, a lower bound for the travelling salesperson problem for this network is found to be 500 km.

By deleting B, and all of its arcs, the corresponding lower bound is found to be 474 km.

(b) Using the results from (a) and the given lower bounds, write down the smallest interval that you can be confident contains the solution to the travelling salesperson problem for this network.

(2)

(Total 7 marks)

2. The table shows the cost, in pounds, of transporting one unit of stock from each of three supply points, A, B and C, to each of four demand points, 1, 2, 3 and 4. It also shows the stock held at each supply point and the stock required at each demand point. A minimum cost solution is required.

	1	2	3	4	Supply
A	15	17	20	11	33
B	12	11	18	21	21
C	18	13	10	16	25
Demand	21	17	28	13	

(a) Use the north-west corner method to obtain an initial solution.

(1)

(b) Taking A4 as the entering cell, use the stepping-stone method to find an improved solution. Make your route clear.

(2)

(c) Taking the most negative improvement index to indicate the entering cell, use the stepping-stone method once to obtain an improved solution. You must make your method clear by stating your shadow costs, improvement indices, route, entering cell and exiting cell.

(4)

(d) Determine whether your current solution is optimal, giving a reason for your answer.

(3)

(Total 10 marks)

3. A two-person zero-sum game is represented by the following pay-off matrix for player A.

	B plays 1	B plays 2	B plays 3
A plays 1	0	–2	6
A plays 2	3	4	1
A plays 3	–1	1	–3

(a) Identify the play safe strategies for each player.

(3)

(b) State, giving a reason, whether there is a stable solution to this game.

(1)

(c) Find the best strategy for player A.

(8)

(d) Find the value of the game to player B.

(1)

(Total 13 marks)

4. Four workers, A, B, C and D, are to be assigned to four tasks, 1, 2, 3 and 4. Each worker must be assigned to only one task and each task must be done by only one worker.

Worker A cannot do task 3 and worker D cannot do task 2

The cost, in pounds, of assigning each worker to each task is shown in the table below.

	1	2	3	4
A	53	84	–	20
B	87	72	41	38
C	70	51	52	25
D	45	–	81	70

The total cost is to be minimised.

Formulate the above situation as a linear programming problem. You must define your decision variables and make the objective function and constraints clear.

You do not need to solve this problem.

(Total 7 marks)

5. The tableau below is the initial tableau for a three-variable linear programming problem in x, y and z. The objective is to maximise the profit, P.

Basic variable	x	y	z	r	s	t	Value
r	15	–2	3	1	0	0	180
s	10	1	1	0	1	0	80
t	1	6	–2	0	0	1	100
P	–1	–2	–5	0	0	0	0

(a) Using the information in the tableau, write down

(i) the objective function,

(ii) the three constraints as inequalities.

(3)

(b) Taking the most negative number in the profit row to indicate the pivot column at each stage, solve this linear programming problem. Make your method clear by stating the row operations you use.

(8)

(c) State the final values of the objective function and each variable.

(2)

(Total 13 marks)

6.

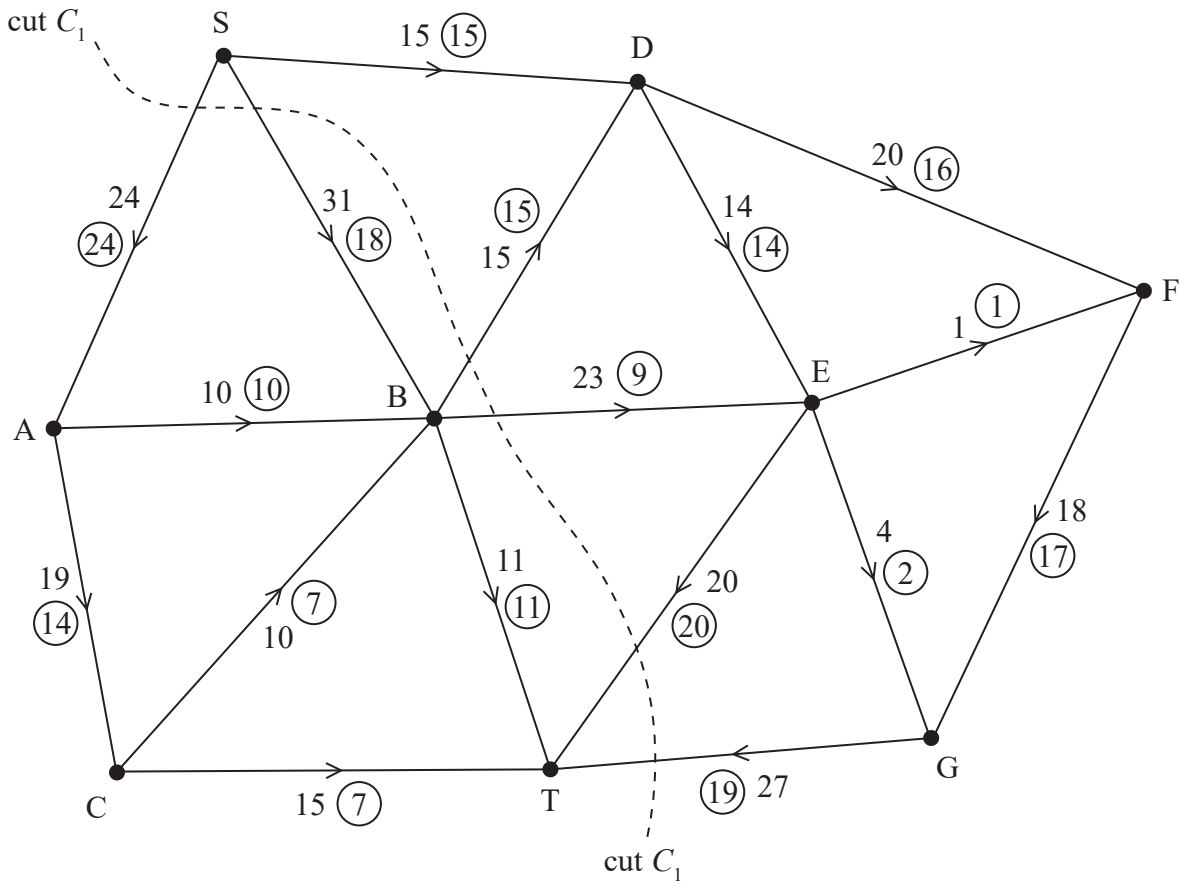


Figure 1

Figure 1 shows a capacitated, directed network. The number on each arc represents the capacity of the corresponding arc. The numbers in circles represent an initial flow from S to T.

(a) State the value of the initial flow.

(1)

(b) State the capacity of cut C_1

(1)

(c) Complete the initialisation of the labelling procedure on Diagram 1 in the answer book by entering values along AC, SB, BE, DE and FG.

(2)

(d) Hence use the labelling procedure to find a maximum flow through the network. You must list each flow-augmenting route you use, together with its flow.

(4)

(e) Draw a maximal flow pattern on Diagram 2 in the answer book.

(2)

(f) Prove that your flow is maximal.

(2)

(Total 12 marks)

7. A clothing manufacturer can export a maximum of five batches of shirts each year.

Each exported batch contains just one type of shirt, the types being T-shirts, Rugby shirts and Polo shirts.

The table below shows the profit, in £1000s, for the number of each exported batch type.

Number of batches	0	1	2	3	4	5
T-shirt	0	55	95	180	230	290
Rugby shirt	0	65	100	160	245	285
Polo shirt	0	70	110	175	225	310

The total annual profit is to be maximised.

(a) Use dynamic programming to determine the maximum annual profit.

(11)

(b) Advise the manufacturer on the possible ways in which the five batches could be allocated.

(2)

(Total 13 marks)

TOTAL FOR PAPER: 75 MARKS

END

Write your name here

Surname	Other names

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Centre Number	Candidate Number

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Total Marks

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1.

	A	B	C	D	E	F
A	–	83	75	82	69	97
B	83	–	94	103	77	109
C	75	94	–	97	120	115
D	82	103	97	–	105	125
E	69	77	120	105	–	88
F	97	109	115	125	88	–

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Question 1 continued

	A	B	C	D	E	F
A	–	83	75	82	69	97
B	83	–	94	103	77	109
C	75	94	–	97	120	115
D	82	103	97	–	105	125
E	69	77	120	105	–	88
F	97	109	115	125	88	–

Q1

(Total 7 marks)

Leave blank

2.

	1	2	3	4	Supply
A	15	17	20	11	33
B	12	11	18	21	21
C	18	13	10	16	25
Demand	21	17	28	13	

(a)

	1	2	3	4	Supply
A					33
B					21
C					25
Demand	21	17	28	13	

	1	2	3	4	Supply
A					33
B					21
C					25
Demand	21	17	28	13	

	1	2	3	4	Supply
A					33
B					21
C					25
Demand	21	17	28	13	

	1	2	3	4	Supply
A					33
B					21
C					25
Demand	21	17	28	13	

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Question 2 continued

	1	2	3	4	Supply
A					33
B					21
C					25
Demand	21	17	28	13	

	1	2	3	4	Supply
A					33
B					21
C					25
Demand	21	17	28	13	

	1	2	3	4	Supply
A					33
B					21
C					25
Demand	21	17	28	13	

	1	2	3	4	Supply
A					33
B					21
C					25
Demand	21	17	28	13	

	1	2	3	4	Supply
A					33
B					21
C					25
Demand	21	17	28	13	

Q2

(Total 10 marks)

Leave blank

3.

	B plays 1	B plays 2	B plays 3
A plays 1	0	–2	6
A plays 2	3	4	1
A plays 3	–1	1	–3

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Question 3 continued

(Total 13 marks)

Q3

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4.

	1	2	3	4
A	53	84	–	20
B	87	72	41	38
C	70	51	52	25
D	45	–	81	70

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Question 4 continued

Q4

(Total 7 marks)

Leave blank

5. (a)

(b) *You may not need to use all of these tableaux*

b.v.	x	y	z	r	s	t	Value
r	15	–2	3	1	0	0	180
s	10	1	1	0	1	0	80
t	1	6	–2	0	0	1	100
P	–1	–2	–5	0	0	0	0

b.v.	x	y	z	r	s	t	Value	Row Ops
P								

b.v.	x	y	z	r	s	t	Value	Row Ops
P								

b.v.	x	y	z	r	s	t	Value	Row Ops
P								

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Question 5 continued

b.v.	x	y	z	r	s	t	Value	Row Ops
P								

b.v.	x	y	z	r	s	t	Value	Row Ops
P								

b.v.	x	y	z	r	s	t	Value	Row Ops
P								

b.v.	x	y	z	r	s	t	Value	Row Ops
P								

(c)

Q5

(Total 13 marks)

6. (a) Value of initial flow _____

(b) Capacity of cut _____

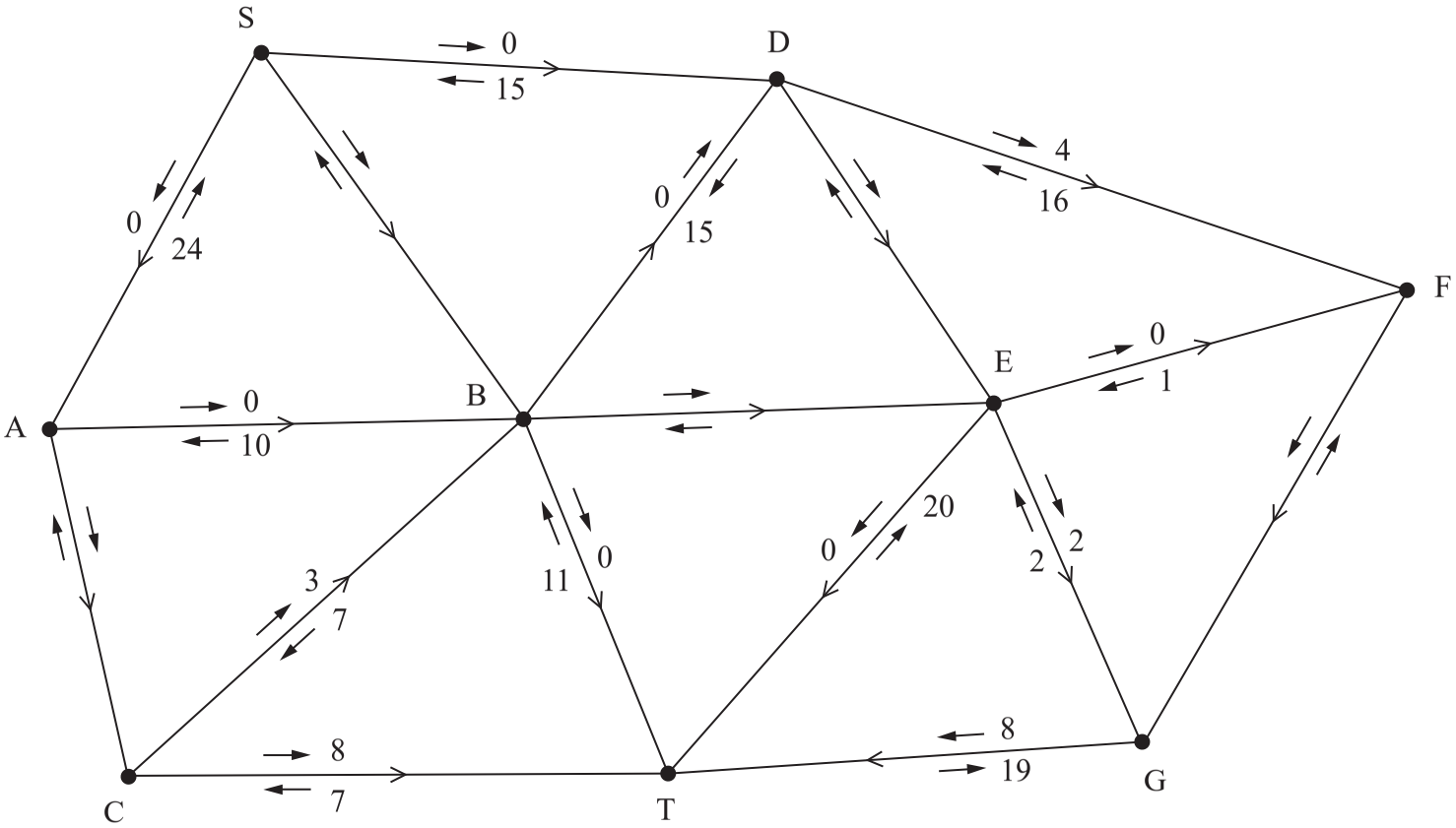


Diagram 1

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Question 6 continued

(d)

(e)

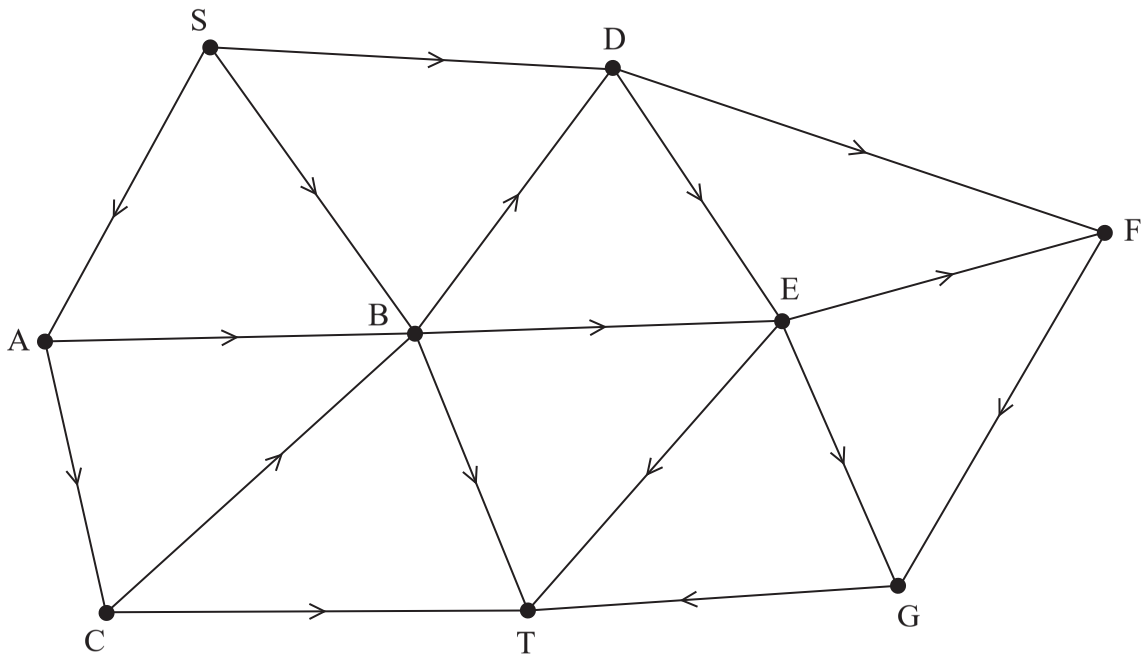


Diagram 2

(f)

(Total 12 marks)

Q6

Leave blank

Leave blank

7. *You may not need to use all the rows of this table*

Stage	State	Action	Dest.	Value
T-shirt				

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DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
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Question 7 continued

Stage	State	Action	Dest.	Value

Maximum annual profit £ ____

Leave blank

Question 7 continued

Q7

(Total 13 marks)

TOTAL FOR PAPER: 75 MARKS

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