Paper Reference(s)

6690/01

Edexcel GCE

Decision Mathematics D2

Advanced/Advanced Subsidiary

Monday 13 June 2011 – Morning

Time: 1 hour 30 minutes

Materials required for examination
Nil

Items included with question papers
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 or symbolic differentiation/integration, or have retrievable mathematical formulae stored in them.

Instructions to Candidates

Write your answers for this paper in the D2 answer book provided.
In the boxes on the answer book, write your centre number, candidate number, your surname, initials and signature.
Check that you have the correct question paper.
Answer ALL the questions.
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 for Candidates

Full marks may be obtained for answers to ALL questions.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 7 questions in this question paper. The total mark for this paper is 75.
There are 12 pages in this question paper. The answer book has 16 pages. Any blank pages are indicated.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You should show sufficient working to make your methods clear to the Examiner.
Answers without working may not gain full credit.

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

1.

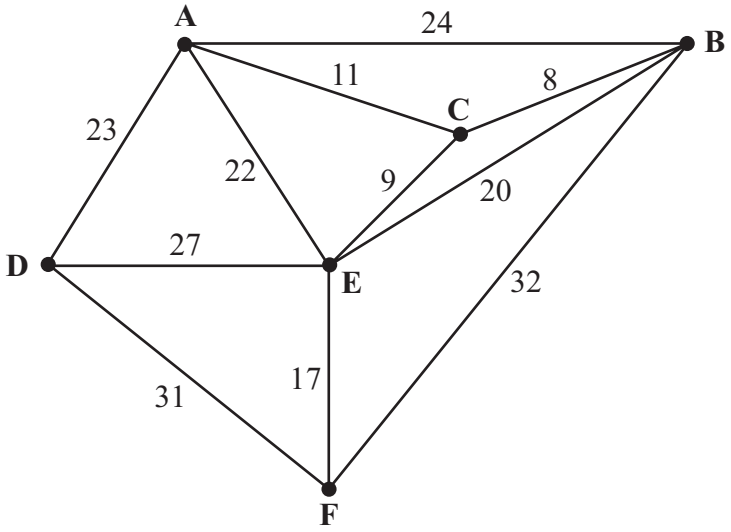


Figure 1

The network in Figure 1 shows the distances, in km, between six towns, A, B, C, D, E and F. Mabintou needs to visit each town. She will start and finish at A and wishes to minimise the total distance travelled.

(a) By inspection, complete the two copies of the table of least distances in your answer book.

(3)

(b) Starting at A, use the nearest neighbour algorithm to find an upper bound for the length of Mabintou's route. Write down the route which gives this upper bound.

(3)

(c) Starting by deleting A, and all of its arcs, find a lower bound for the route length.

(4)

(Total 10 marks)

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

	A	B	C	Supply
1	31	29	32	20
2	22	33	27	22
3	25	27	32	20
4	23	26	38	38
Demand	35	25	30	

(a) Add a dummy demand point and appropriate values to Table 1 in the answer book.

(1)

Table 2 shows an initial solution given by the north-west corner method.
Table 3 shows some of the improvement indices for this solution.

	A	B	C	D
1	20			
2	15	7		
3		18	2	
4			28	10

Table 2

	A	B	C	D
1		–13		–9
2			–11	
3				
4	1	–7		

Table 3

(b) Calculate the shadow costs and the missing improvement indices and enter them into Table 3 in the **answer book**.

(4)

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

(4)

(Total 9 marks)

3. A three-variable linear programming problem in x, y and z is to be solved. The objective is to maximise the profit, P.
The following tableau is obtained.

Basic variable	x	y	z	r	s	t	Value
r	$-\frac{1}{2}$	0	2	1	$-\frac{1}{2}$	0	10
y	$\frac{1}{2}$	1	$\frac{3}{4}$	0	$\frac{1}{4}$	0	5
t	$\frac{1}{2}$	0	1	0	$-\frac{1}{4}$	1	4
P	–7	0	1	0	4	0	320

(a) Write down the profit equation represented in the tableau.

(2)

(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.

(5)

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

(3)

(Total 10 marks)

4. Laura and Sam play a zero-sum game. This game is represented by the following pay-off matrix for Laura.

	S plays 1	S plays 2	S plays 3
L plays 1	–4	–1	1
L plays 2	3	–1	–2
L plays 3	–3	0	2

Find the best strategy for Laura and the value of the game to her.

(Total 9 marks)

5.

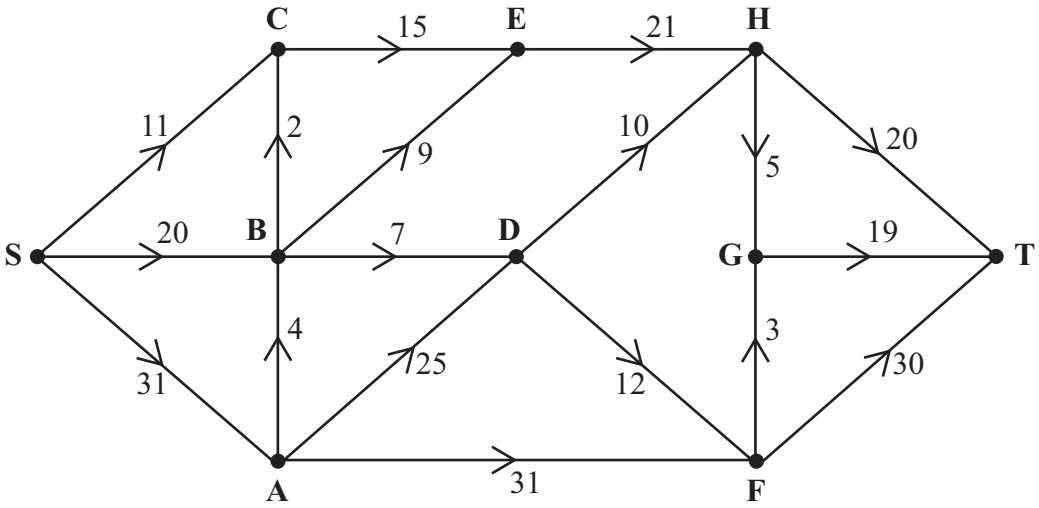


Figure 2

Figure 2 shows a capacitated directed network. The number on each arc is its capacity.

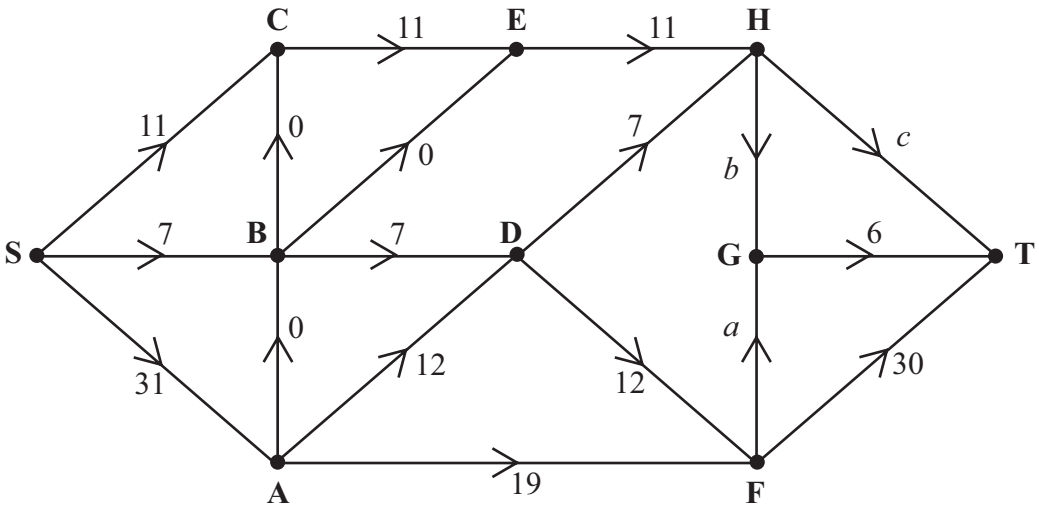


Figure 3

Figure 3 shows an initial flow through the same network.

(a) State the values of flows a, b and c, and the value of the initial flow.

(4)

(b) By entering values along HG, HT and FG, complete the labelling procedure on Diagram 1 in the answer book.

(2)

(c) Find the maximum flow through the network. You must list each flow-augmenting route you use, together with its flow.

(4)

(d) State the value of the maximum flow through the network.

(1)

(e) Show your maximum flow on Diagram 2 in the answer book.

(2)

(f) Prove that your flow is maximal.

(2)

(Total 15 marks)

6. Three workers, P, Q and R, are to be assigned to three tasks, A, B and C. Each worker must be assigned to just one task and each task must be assigned to just one worker.
Table 1 shows the cost of using each worker for each task. The total cost is to be minimised.

	Task A	Task B	Task C
Worker P	27	31	25
Worker Q	26	30	34
Worker R	35	29	32

Table 1

(a) Formulate the above situation as a linear programming problem. You must define your decision variables and make the objective and constraints clear.
You are not required to solve the problem.

(7)

Table 2 shows the profit gained by using each worker for each task. The total profit is to be maximised.

	Task A	Task B	Task C
Worker P	33	37	31
Worker Q	32	36	40
Worker R	41	35	38

Table 2

(b) Modify Table 2 in the answer book so that the Hungarian Algorithm could be used to find the maximum total profit. You are not required to solve the problem.

(2)

(Total 9 marks)

7. Patrick is to take orders for his company's products.
He will visit four countries over the next four weeks.
He will visit just one country each week.
He will leave from his office in London and will only return there after visiting the four countries.
He will travel directly from one country to the next.
He wishes to determine a schedule of four countries to visit.

Table 1 shows the countries he could visit in each week.

Week	Week 1	Week 2	Week 3	Week 4
Possible countries	A or B	C, D or E	F or G	H or I

Table 1

Table 2 shows the value of the orders, in £100s, he expects to take in each country.

Country	A	B	C	D	E	F	G	H	I
Value of expected orders in £100s	22	17	42	41	39	29	27	36	38

Table 2

Table 3 shows the cost, in £100s, of travelling between the various countries.

Travel costs in £100s	A	B	C	D	E	F	G	H	I
London	5	3						5	4
A			5	4	2				
B			4	4	3				
C						6	5		
D						6	3		
E						4	4		
F								6	7
G								5	6

Table 3

The expected income is the value of the expected orders minus the cost of travel.

It is decided to use dynamic programming to find a schedule that maximises the total expected income for these four weeks.

(a) Complete the table in the answer book to determine the optimal expected income.

(11)

(b) State Patrick's two optimal schedules.

(2)

(Total 13 marks)

TOTAL FOR PAPER: 75 MARKS

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Candidate No.						6	6	9	0	/	0	1	Signature	

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Edexcel GCE

Decision Mathematics D2

Advanced/Advanced Subsidiary

Monday 13 June 2011 – Morning

Answer Book

Do not return the question paper with the answer book

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Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
Total	

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1. (a)

	A	B	C	D	E	F
A	-	19	11	23	20	
B	19	-	8		17	32
C	11	8	-		9	26
D	23			-	27	31
E	20	17	9	27	-	17
F		32	26	31	17	-

Table of least distances

(b)

(c)

	A	B	C	D	E	F
A	-	19	11	23	20	
B	19	-	8		17	32
C	11	8	-		9	26
D	23			-	27	31
E	20	17	9	27	-	17
F		32	26	31	17	-

Table of least distances

P 3 5 4 1 9 A 0 2 1 6

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Question 1 continued

Q1

(Total 10 marks)

Leave blank

2. (a)

	A	B	C	Dummy	Supply
1	31	29	32		20
2	22	33	27		22
3	25	27	32		20
4	23	26	38		38
Demand	35	25	30		

Table 1

(b)

	A	B	C	D
1	20			
2	15	7		
3		18	2	
4			28	10

Table 2

	A	B	C	D
1	×	–13		–9
2	×	×	–11	
3		×	×	
4	1	–7	×	×

Table 3

(c)

You may not need to use all these tables

	A	B	C	D
1				
2				
3				
4				

Leave blank

Question 2 continued

	A	B	C	D
1				
2				
3				
4				

	A	B	C	D
1				
2				
3				
4				

	A	B	C	D
1				
2				
3				
4				

	A	B	C	D
1				
2				
3				
4				

	A	B	C	D
1				
2				
3				
4				

Q2

(Total 9 marks)

Leave blank

3. (a) _____

_____

_____

(b)

b.v.	x	y	z	r	s	t	Value
r	$-\frac{1}{2}$	0	2	1	$-\frac{1}{2}$	0	10
y	$\frac{1}{2}$	1	$\frac{3}{4}$	0	$\frac{1}{4}$	0	5
t	$\frac{1}{2}$	0	1	0	$-\frac{1}{4}$	1	4
P	–7	0	1	0	4	0	320

You may not need to use all of these tableaux

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								

Leave blank

Question 3 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								

(c)

Q3

(Total 10 marks)

Leave blank

4.

	S plays 1	S plays 2	S plays 3
L plays 1	–4	–1	1
L plays 2	3	–1	–2
L plays 3	–3	0	2

Leave blank

Question 4 continued

Q4

(Total 9 marks)

10

5 (a) $a =$ _____ , $b =$ _____, $c =$ _____ , value of initial flow: _____

(b)

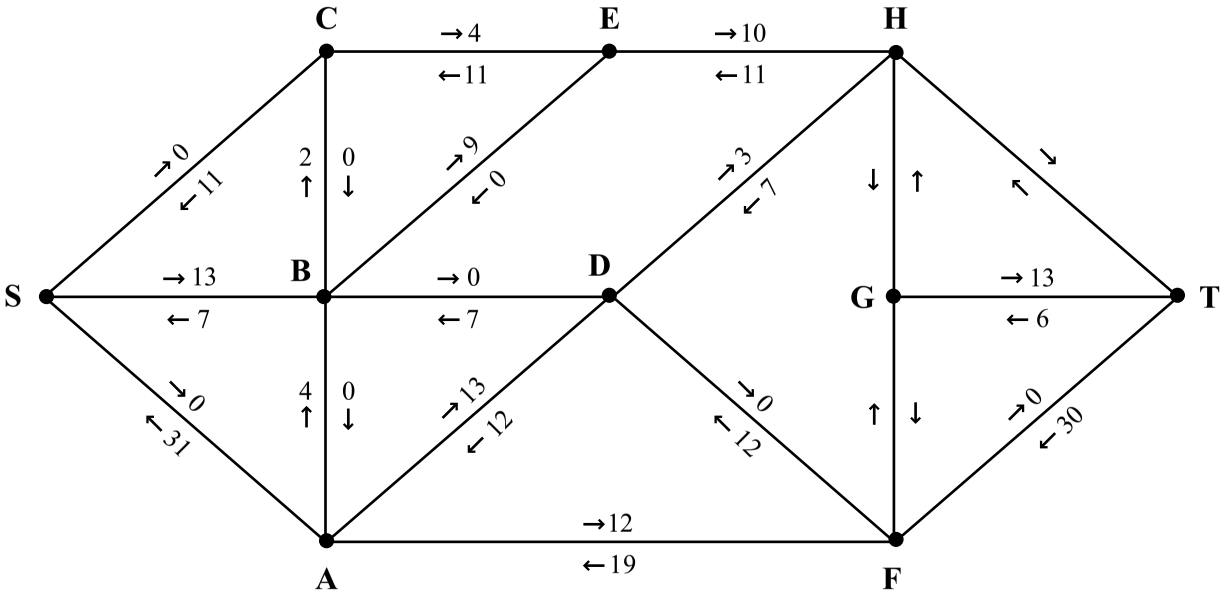


Diagram 1

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P 3 5 4 1 9 A 0 1 0 1 6

Question 5 continued

(c) _____

_____

_____

(d) Value of maximum flow: _____

(e)

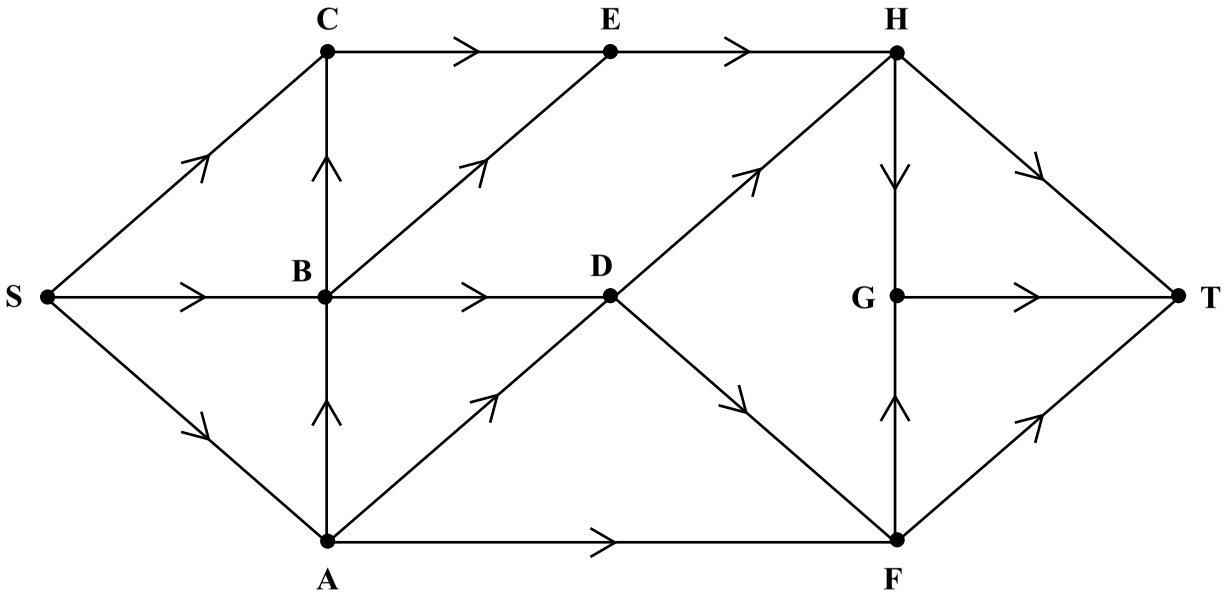


Diagram 2

(f) _____

_____

_____

(Total 15 marks)

Q5

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P 3 5 4 1 9 A 0 1 1 1 6

Leave blank

6. (a)

	Task A	Task B	Task C
Worker P	27	31	25
Worker Q	26	30	34
Worker R	35	29	32

Table 1

Leave blank

Question 6 continued

(b)

	Task A	Task B	Task C
Worker P	33	37	31
Worker Q	32	36	40
Worker R	41	35	38

Table 2

	Task A	Task B	Task C
Worker P			
Worker Q			
Worker R			

Q6

(Total 9 marks)

Leave blank

7. (a)

Stage	State	Action	Destination	Value
0	H	H – London	London	36 – 5 = 31*
	I	I – London	London	38 – 4 = 34*
1	F	FH	H	29 – 6 + 31 = 54
		FI	I	29 – 7 + 34 = 56*
	G	GH		

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Question 7 continued

Stage	State	Action	Destination	Value

Optimal expected income: _____

(b) _____

Q7

(Total 13 marks)

TOTAL FOR PAPER: 75 MARKS

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