Paper Reference(s)

6690/01

Edexcel GCE

Decision Mathematics D2

Advanced/Advanced Subsidiary

Thursday 31 May 2012 – 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 8 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 20 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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PEARSON

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

1. Five workers, A, B, C, D and E, are to be assigned to five tasks, 1, 2, 3, 4 and 5. Each worker is to be assigned to one task and each task must be assigned to one worker.

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

	1	2	3	4	5
A	129	127	122	134	135
B	127	125	123	131	132
C	142	131	121	140	139
D	127	127	122	131	136
E	141	134	129	144	143

(a) **Reducing rows first**, use the Hungarian algorithm to obtain an allocation that minimises the cost. You must make your method clear and show the table after each stage.

(8)

(b) Find the minimum cost.

(1)

(Total 9 marks)

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

	A	B	C	D	E	F
A	-	16	25	21	12	15
B	16	-	24	22	21	12
C	25	24	-	18	30	27
D	21	22	18	-	15	12
E	12	21	30	15	-	18
F	15	12	27	12	18	-

Toby must visit each town at least once. He will start and finish at A and wishes to minimise the total distance.

(a) Use the nearest neighbour algorithm, starting at A, to find an upper bound for the length of Toby's route.

(3)

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

(4)

(Total 7 marks)

3. The table below shows the cost, in pounds, of transporting one tonne of concrete from each of three supply depots, A, B and C, to each of four building sites, D, E, F and G. It also shows the number of tonnes that can be supplied from each depot and the number of tonnes required at each building site. A minimum cost solution is required.

	D	E	F	G	Supply
A	17	19	21	20	18
B	21	20	19	22	23
C	18	17	16	21	29
Demand	15	24	18	13	

The north-west corner method gives the following possible solution.

	D	E	F	G	Supply
A	15	3			18
B		21	2		23
C			16	13	29
Demand	15	24	18	13	

Taking AG as the first entering cell,

(a) use the stepping stone method **twice** to obtain an improved solution. You must make your method clear by stating your shadow costs, improvement indices, routes, entering cells and exiting cells.

(8)

(b) Determine whether your current solution is optimal. Justify your answer.

(4)

(Total 12 marks)

4. The tableau below is the initial tableau for a maximising linear programming problem in x, y and z which is to be solved.

Basic variable	x	y	z	r	s	t	Value
r	5	$\frac{1}{2}$	0	1	0	0	5
s	1	–2	4	0	1	0	3
t	8	4	6	0	0	1	6
P	–5	–7	–4	0	0	0	0

(a) Starting by increasing y, perform one complete iteration of the simplex algorithm, to obtain tableau T. State the row operations you use.

(5)

(b) Write down the profit equation given by tableau T.

(2)

(c) Use the profit equation from part (b) to explain why tableau T is optimal.

(1)

(Total 8 marks)

5. Agent Goodie is planning to break into Evil Doctor Fiendish's secret base.

He uses game theory to determine whether to approach the base from air, sea or land.

Evil Doctor Fiendish decides each day which of three possible plans he should use to protect his base.

Agent Goodie evaluates the situation. He assigns numbers, negative indicating he fails in his mission, positive indicating success, to create a pay-off matrix. The numbers range from –3 (he fails in his mission and is captured) to 5 (he successfully achieves his mission and escapes uninjured) and the pay-off matrix is shown below.

	Fiendish uses plan 1	Fiendish uses plan 2	Fiendish uses plan 3
Air	0	4	5
Sea	2	–3	1
Land	–2	3	–2

(a) Reduce the game so that Agent Goodie has only two choices, explaining your reasoning.

(1)

(b) Use game theory to determine Agent Goodie's best strategy.

(7)

(c) Find the value of the game to Agent Goodie.

(1)

(Total 9 marks)

6.

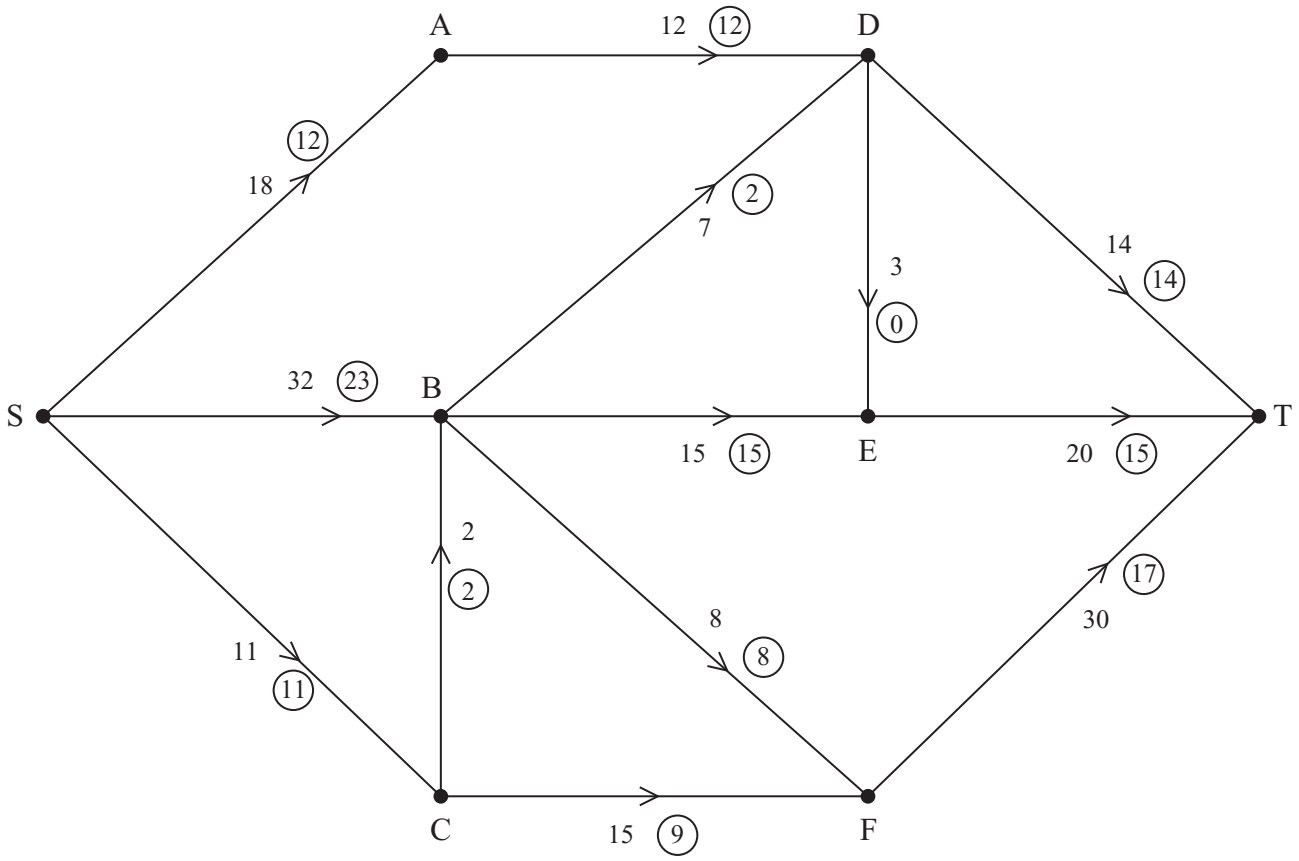


Figure 1

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

(a) State the value of the initial flow.

(1)

(b) Complete the initialisation of the labelling procedure on Diagram 1 in the answer book by entering values along SB, BD, CF and FT.

(2)

(c) 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)

(d) Draw a maximal flow pattern on Diagram 2 in your answer book.

(2)

(e) Prove that your flow is maximal.

(2)

(Total 11 marks)

7. Four workers, A, B, C and D, are to be assigned to four tasks, P, Q, R and S. Each worker is to be assigned to exactly one task and each task must be assigned to just one worker. The cost, in pounds, of using each worker for each task is given in the table below. The total cost is to be minimised.

	P	Q	R	S
A	23	41	34	44
B	21	45	33	42
C	26	43	31	40
D	20	47	35	46

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

(Total 7 marks)

8. A company makes industrial robots.
They can make up to four robots in any one month, but if they make more than three they will have to hire additional labour at a cost of £400 per month.
They can store up to two robots at a cost of £150 per robot per month.
The overhead costs are £300 in any month in which work is done.

Robots are delivered to buyers at the end of each month. There are no robots in stock at the beginning of January and there should be none in stock after the April delivery.

The order book for robots is

Month	January	February	March	April
Number of robots required	2	2	3	4

Use dynamic programming to determine the production schedule which minimises the costs, showing your working in the table provided in the answer book.

(Total 12 marks)

TOTAL FOR PAPER: 75 MARKS

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Candidate No.						6	6	9	0	/	0	1	Signature	

Paper Reference(s)

6690/01

Edexcel GCE

Decision Mathematics D2

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Thursday 31 May 2012 – Morning

Answer Book

Do not return the question paper with the answer book

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
8	
Total	

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PEARSON

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1.

	1	2	3	4	5
A	129	127	122	134	135
B	127	125	123	131	132
C	142	131	121	140	139
D	127	127	122	131	136
E	141	134	129	144	143

	1	2	3	4	5
A					
B					
C					
D					
E					

	1	2	3	4	5
A					
B					
C					
D					
E					

	1	2	3	4	5
A					
B					
C					
D					
E					

	1	2	3	4	5
A					
B					
C					
D					
E					

Leave blank

Question 1 continued

	1	2	3	4	5
A					
B					
C					
D					
E					

	1	2	3	4	5
A					
B					
C					
D					
E					

	1	2	3	4	5
A					
B					
C					
D					
E					

	1	2	3	4	5
A					
B					
C					
D					
E					

	1	2	3	4	5
A					
B					
C					
D					
E					

Q1

(Total 9 marks)

Leave blank

2. (a)

	A	B	C	D	E	F
A	-	16	25	21	12	15
B	16	-	24	22	21	12
C	25	24	-	18	30	27
D	21	22	18	-	15	12
E	12	21	30	15	-	18
F	15	12	27	12	18	-

Leave blank

Question 2 continued

(b)

	A	B	C	D	E	F
A	-	16	25	21	12	15
B	16	-	24	22	21	12
C	25	24	-	18	30	27
D	21	22	18	-	15	12
E	12	21	30	15	-	18
F	15	12	27	12	18	-

Q2

(Total 7 marks)

Leave blank

3.

	D	E	F	G	Supply
A	17	19	21	20	18
B	21	20	19	22	23
C	18	17	16	21	29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

Leave blank

Question 3 continued

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

	D	E	F	G	Supply
A					18
B					23
C					29
Demand	15	24	18	13	

(Total 12 marks)

Q3

Leave blank

4.

b.v.	x	y	z	r	s	t	Value
r	5	$\frac{1}{2}$	0	1	0	0	5
s	1	–2	4	0	1	0	3
t	8	4	6	0	0	1	6
P	–5	–7	–4	0	0	0	0

(a) *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 4 continued

Q4

(Total 8 marks)

Leave blank

5.

	Fiendish uses plan 1	Fiendish uses plan 2	Fiendish uses plan 3
Air	0	4	5
Sea	2	–3	1
Land	–2	3	–2

Leave blank

Question 5 continued

Q5

(Total 9 marks)

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6. (a) Value of initial flow _____

(b)

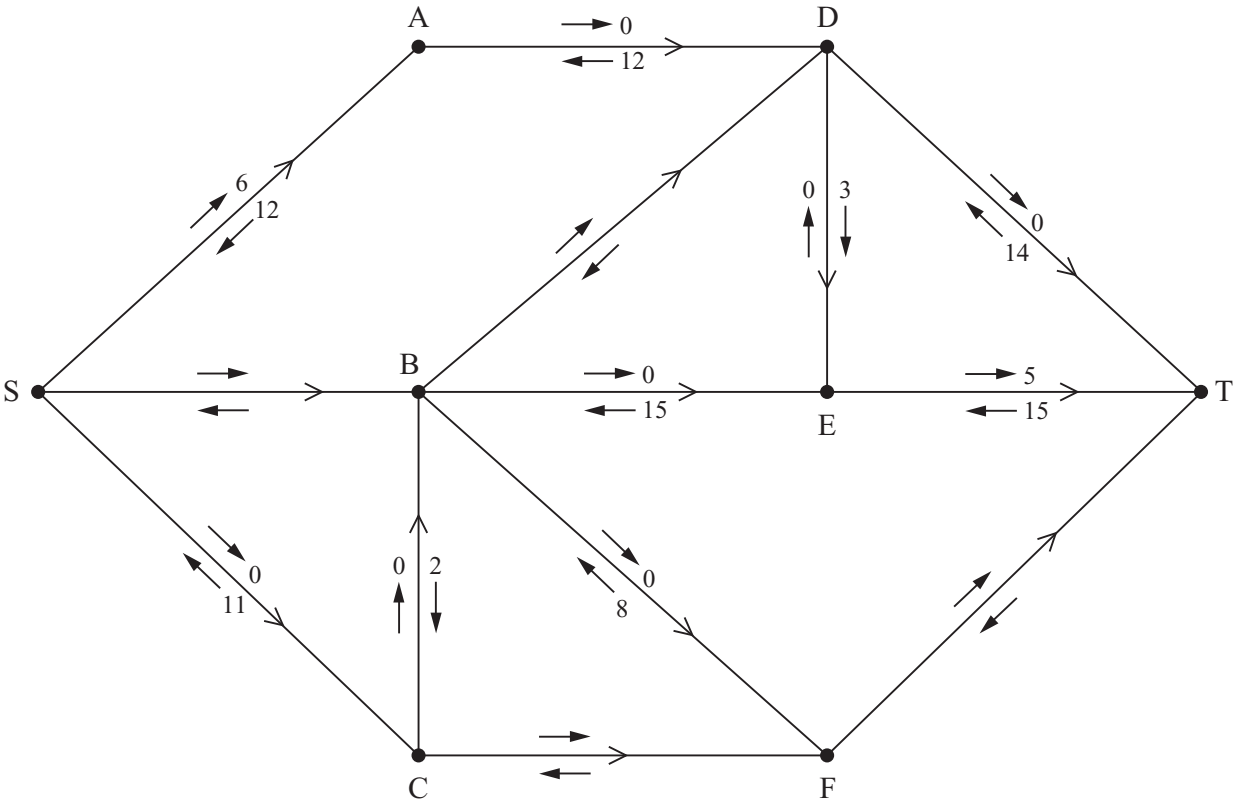


Diagram 1

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Question 6 continued

(c)

(d)

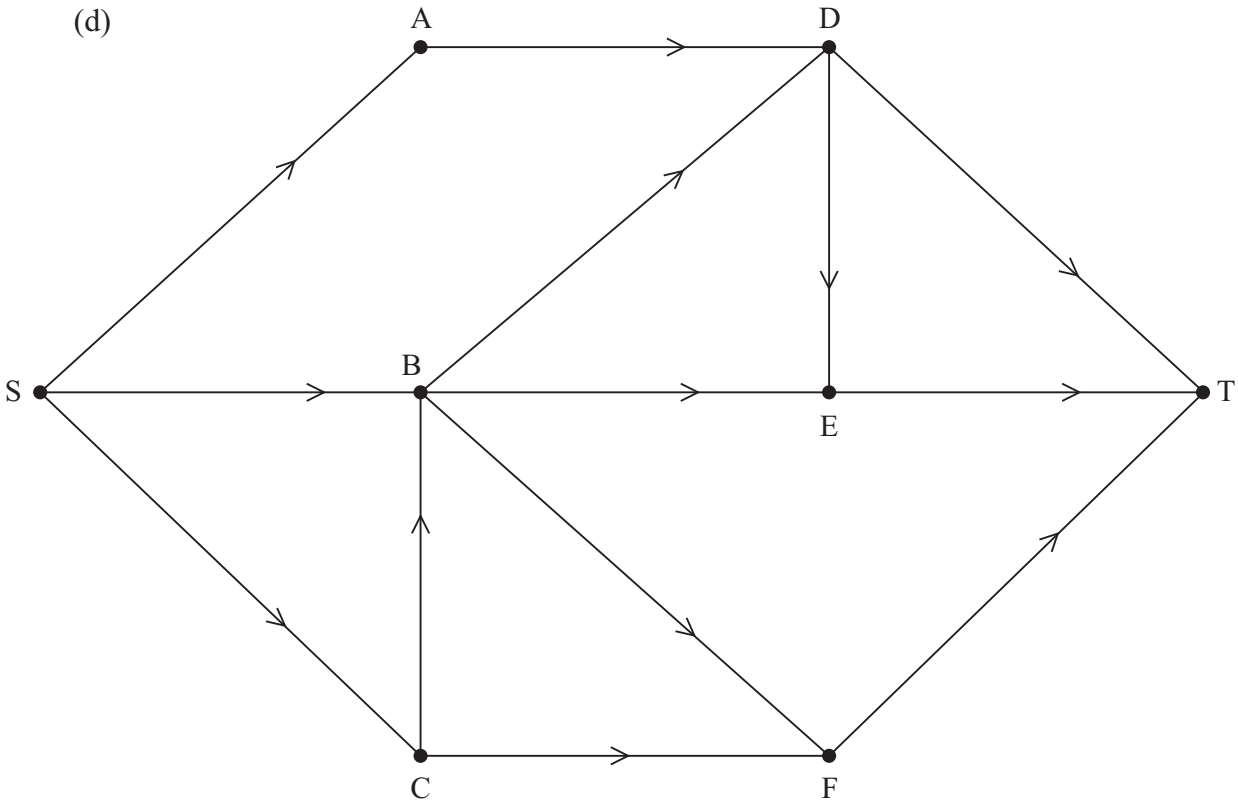


Diagram 2

(e)

Q6

(Total 11 marks)

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7.

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Question 7 continued

Q7

(Total 7 marks)

Leave blank

8. *You may not need to use all of these rows*

Stage (Month)	**State** (Number of robots in store at start of month)	**Action** (Number of robots made during month)	**Dest**. (Number of robots in store at end of month)	**Value**

Leave blank

Question 8 continued

Stage	State	Action	Dest.	Value

Month	Jan	Feb	March	April
Number of robots made				

Q8

(Total 12 marks)

TOTAL FOR PAPER: 75 MARKS

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