Paper Reference(s)

6690/01

Edexcel GCE

Decision Mathematics D2

Advanced/Advanced Subsidiary

Tuesday 24 June 2014 – 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 8 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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PEARSON

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

1. 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 just one task and each task must be done by just one worker.

Worker A cannot do task 4 and worker B cannot do task 2.

The amount, in pounds, that each worker would earn if assigned to the tasks, is shown in the table below.

	1	2	3	4
A	19	16	23	–
B	24	–	30	23
C	18	17	25	18
D	24	24	26	24

Reducing rows first, use the Hungarian algorithm to obtain an allocation that maximises the total earnings. You must make your method clear and show the table after each stage.

(Total 10 marks)

2. The table shows the least times, in seconds, that it takes a robot to travel between six points in an automated warehouse. These six points are an entrance, A, and five storage bins, B, C, D, E and F. The robot will start at A, visit each bin, and return to A. The total time taken for the robot's route is to be minimised.

	A	B	C	D	E	F
A	–	90	130	85	35	125
B	90	–	80	100	83	88
C	130	80	–	108	106	105
D	85	100	108	–	110	88
E	35	83	106	110	–	75
F	125	88	105	88	75	–

(a) Show that there are two nearest neighbour routes that start from A. You must make the routes and their lengths clear.

(4)

(b) Starting by deleting F, and all of its arcs, find a lower bound for the time taken for the robot's route.

(3)

(c) Use your results to write down the smallest interval which you are confident contains the optimal time for the robot's route.

(3)

(Total 10 marks)

3. 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	5	3	$-\frac{1}{2}$	1	0	0	2500
s	3	2	1	0	1	0	1650
t	$\frac{1}{2}$	–1	2	0	0	1	800
P	–40	–50	–35	0	0	0	0

(a) 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.

(10)

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

(2)

(Total 12 marks)

4. 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	B plays 4
A plays 1	2	–1	1	–3
A plays 2	–3	2	–2	1

(a) Verify that there is no stable solution to this game.

(2)

(b) Find the best strategy for player A.

(9)

(Total 11 marks)

5.

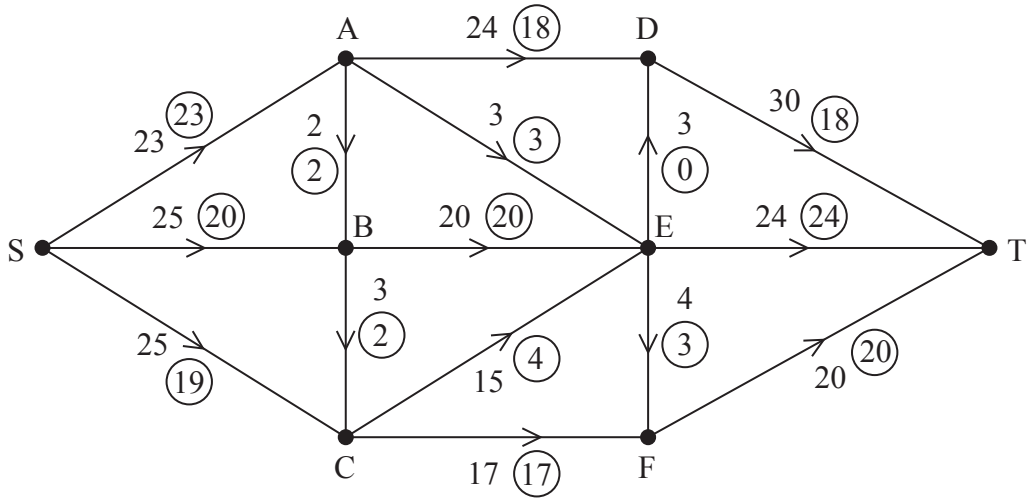


Figure 1

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 SC, AB, CE, DE and DT.

(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 the answer book.

(2)

(e) Prove that your flow is maximal.

(2)

(Total 11 marks)

6. Three warehouses, P, Q and R, supply washing machines to four retailers, A, B, C and D. The table gives the cost, in pounds, of transporting a washing machine from each warehouse to each retailer. It also shows the number of washing machines held at each warehouse and the number of washing machines required by each retailer. The total cost of transportation is to be minimised.

	A	B	C	D	Supply
P	11	22	13	17	25
Q	21	8	19	14	27
R	15	10	9	12	28
Demand	18	16	20	26	

Formulate this transportation problem 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)

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7. A company assembles microlight aircraft.
They can assemble up to four aircraft in any one month, but if they assemble more than three they will have to hire additional space at a cost of £1000 per month.
They can store up to two aircraft at a cost of £500 each per month.
The overhead costs are £2000 in any month in which work is done.

Aircraft are delivered at the end of each month. There are no aircraft in stock at the beginning of March and there should be none in stock at the end of July.
The order book for aircraft is

Month	March	April	May	June	July
Number ordered	3	4	2	4	3

Use dynamic programming to determine the production schedule which minimises the costs. Show your working in the table provided in the answer book and state the minimum production cost.

(Total 14 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

Advanced/Advanced Subsidiary

Tuesday 24 June 2014 – 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	
Total	

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PEARSON

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1.

	1	2	3	4
A	19	16	23	–
B	24	–	30	23
C	18	17	25	18
D	24	24	26	24

	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
A				
B				
C				
D				

Leave blank

Question 1 continued

	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
A				
B				
C				
D				

Q1

(Total 10 marks)

Leave blank

2.

	A	B	C	D	E	F
A	–	90	130	85	35	125
B	90	–	80	100	83	88
C	130	80	–	108	106	105
D	85	100	108	–	110	88
E	35	83	106	110	–	75
F	125	88	105	88	75	–

Leave blank

Question 2 continued

	A	B	C	D	E	F
A	–	90	130	85	35	125
B	90	–	80	100	83	88
C	130	80	–	108	106	105
D	85	100	108	–	110	88
E	35	83	106	110	–	75
F	125	88	105	88	75	–

Q2

(Total 10 marks)

Leave blank

3.

b.v.	x	y	z	r	s	t	Value
r	5	3	$-\frac{1}{2}$	1	0	0	2500
s	3	2	1	0	1	0	1650
t	$\frac{1}{2}$	–1	2	0	0	1	800
P	–40	–50	–35	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 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								

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

(b)

Q3

(Total 12 marks)

Leave blank

4.

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

Leave blank

Question 4 continued

Q4

(Total 11 marks)

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5. (a) Initial flow value: _____

(b)

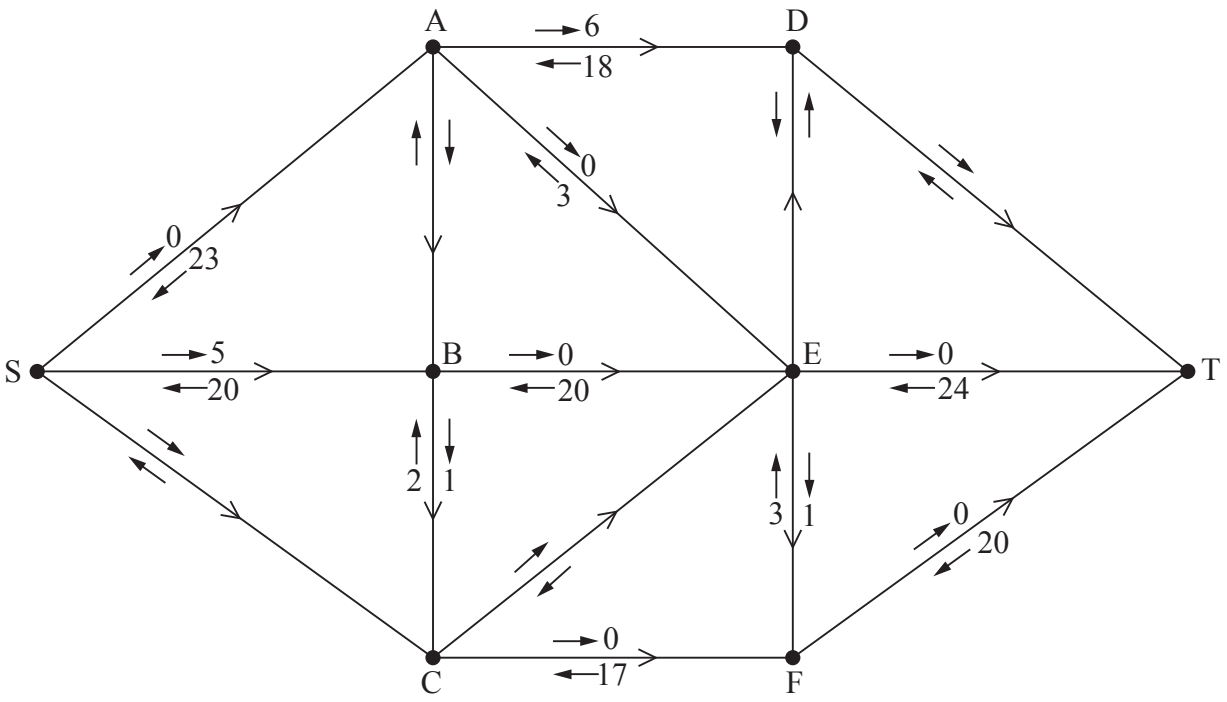


Diagram 1

(c)

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Question 5 continued

(d)

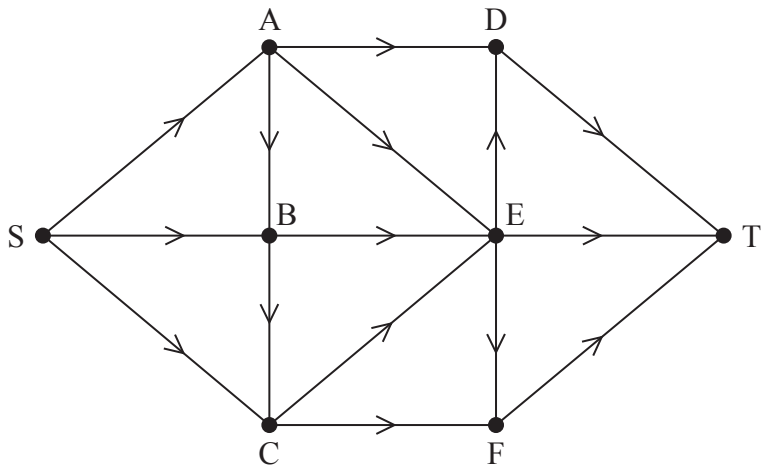


Diagram 2

(e)

Q5

(Total 11 marks)

Leave blank

6.

	A	B	C	D	Supply
P	11	22	13	17	25
Q	21	8	19	14	27
R	15	10	9	12	28
Demand	18	16	20	26	

Leave blank

Question 6 continued

Q6

(Total 7 marks)

Leave blank

7.

Month	March	April	May	June	July
Number ordered	3	4	2	4	3

You may not need to use all of these rows

Stage	**State**	**Action**	**Dest.**	**Value**

Leave blank

Question 7 continued

Stage	State	Action	Dest.	Value

Production schedule

Month	March	April	May	June	July
Number made					

Minimum production cost £ _____

Q7

(Total 14 marks)

TOTAL FOR PAPER: 75 MARKS

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