Pearson Edexcel Level 3 GCE

Further Mathematics

**Advanced Subsidiary
Further Mathematics options
28: Decision Mathematics 2
(Part of option K only)**

You must have:
Mathematical Formulae and Statistical Tables (Green),
calculator, D2 Answer Book (enclosed)

**Candidates may use any calculator permitted by Pearson regulations.
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).
- **Fill in the boxes** at 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 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.
- Inexact answers should be given to three significant figures unless otherwise stated.
- Do not return the question paper with the D2 Answer Book.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- The total mark for this part of the examination is 40. There are 4 questions.
- 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. Four workers, A, B, C and D, are each to be assigned to one of four tasks, P, Q, R and S.

   Each worker must be assigned to one task, and each task must be done by exactly one worker.

   Worker C cannot be assigned to task Q and worker D cannot be assigned to task S.

   The time, in minutes, that each worker takes to complete each task is shown in the table below.

	P	Q	R	S
A	54	48	51	52
B	55	51	53	58
C	52	–	53	54
D	67	63	68	–

   The Hungarian algorithm is to be used to find the minimum total time for the four workers to complete the tasks.

   (a) Modify the table so that the Hungarian algorithm may be used.

   (1)

   (b) Reducing rows first, use the Hungarian algorithm to obtain an allocation that minimises the total time. You should explain how any initial row and column reductions are made and also how you determine if the table is optimal at each stage.

   (6)
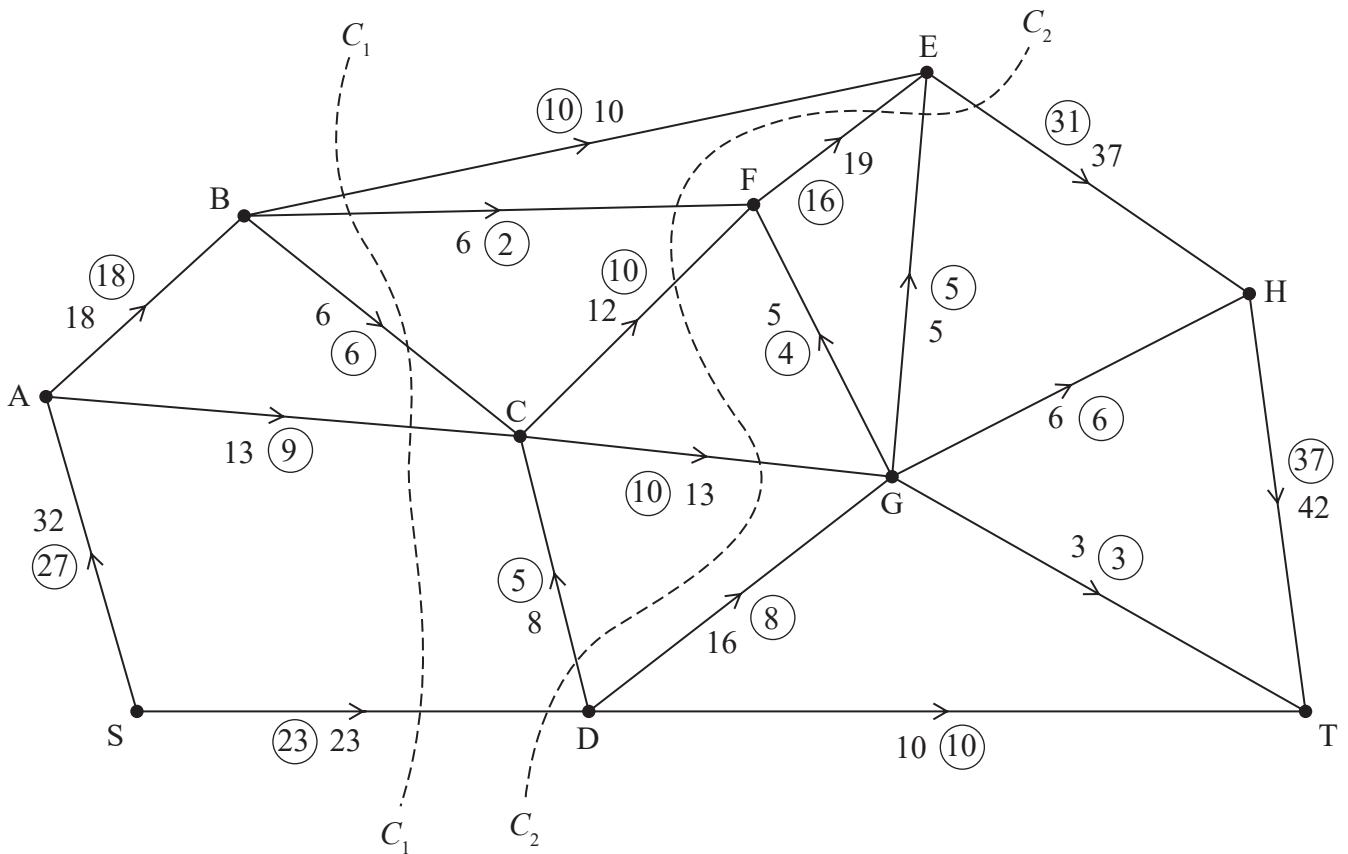
   (Total for Question 1 is 7 marks)

2.

Figure 1

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

(a) State the value of this flow.

(1)

(b) List the eight saturated arcs.

(1)

(c) Explain why arc EH can never be full to capacity.

(1)

(d) Find the capacity of

   (i) cut C_1

   (ii) cut C_2

(2)

(e) Write down a flow-augmenting route that increases the flow by three units.

(1)

Given that the flow through the network is increased by three units,

(f) prove that this new flow is maximal.

(3)

(Total for Question 2 is 9 marks)

3. Terry and June play a zero-sum game. The pay-off matrix shows the number of points that Terry scores for each combination of strategies.

		June	
		Option X	Option Y
Terry	Option A	1	4
	Option B	–2	6
	Option C	–1	5
	Option D	8	–4

(a) Explain the meaning of 'zero-sum' game.

(1)

(b) Verify that there is no stable solution to the game.

(2)

(c) Write down the pay-off matrix for June.

(1)

(d) (i) Find the best strategy for June, defining any variables you use.

(ii) State the value of the game to Terry.

(7)

Let Terry play option A with probability t.

(e) By writing down a linear equation in t, find the best strategy for Terry.

(3)

(Total for Question 3 is 14 marks)

4. A sequence $\{u_n\}$, where $n \geqslant 0$, satisfies the recurrence relation

$$u_{n+1} + 3u_n = n + k$$

where k is a non-zero constant.

Given that $u_0 = 1$

(a) solve the recurrence relation, giving u_n in terms of k and n.

(7)

Given that u_n is a linear function of n,

(b) use your answer to part (a) to find the value of u_{100}

(3)

(Total for Question 4 is 10 marks)

TOTAL FOR DECISION MATHEMATICS 2 IS 40 MARKS

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Answer Book
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Total Marks

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1.

	P	Q	R	S
A	54	48	51	52
B	55	51	53	58
C	52	–	53	54
D	67	63	68	–

You may not need to use all of these tables.

	P	Q	R	S
A				
B				
C				
D				

	P	Q	R	S
A				
B				
C				
D				

	P	Q	R	S
A				
B				
C				
D				

Question 1 continued

	P	Q	R	S
A				
B				
C				
D				

	P	Q	R	S
A				
B				
C				
D				

	P	Q	R	S
A				
B				
C				
D				

	P	Q	R	S
A				
B				
C				
D				

	P	Q	R	S
A				
B				
C				
D				

(Total for Question 1 is 7 marks)
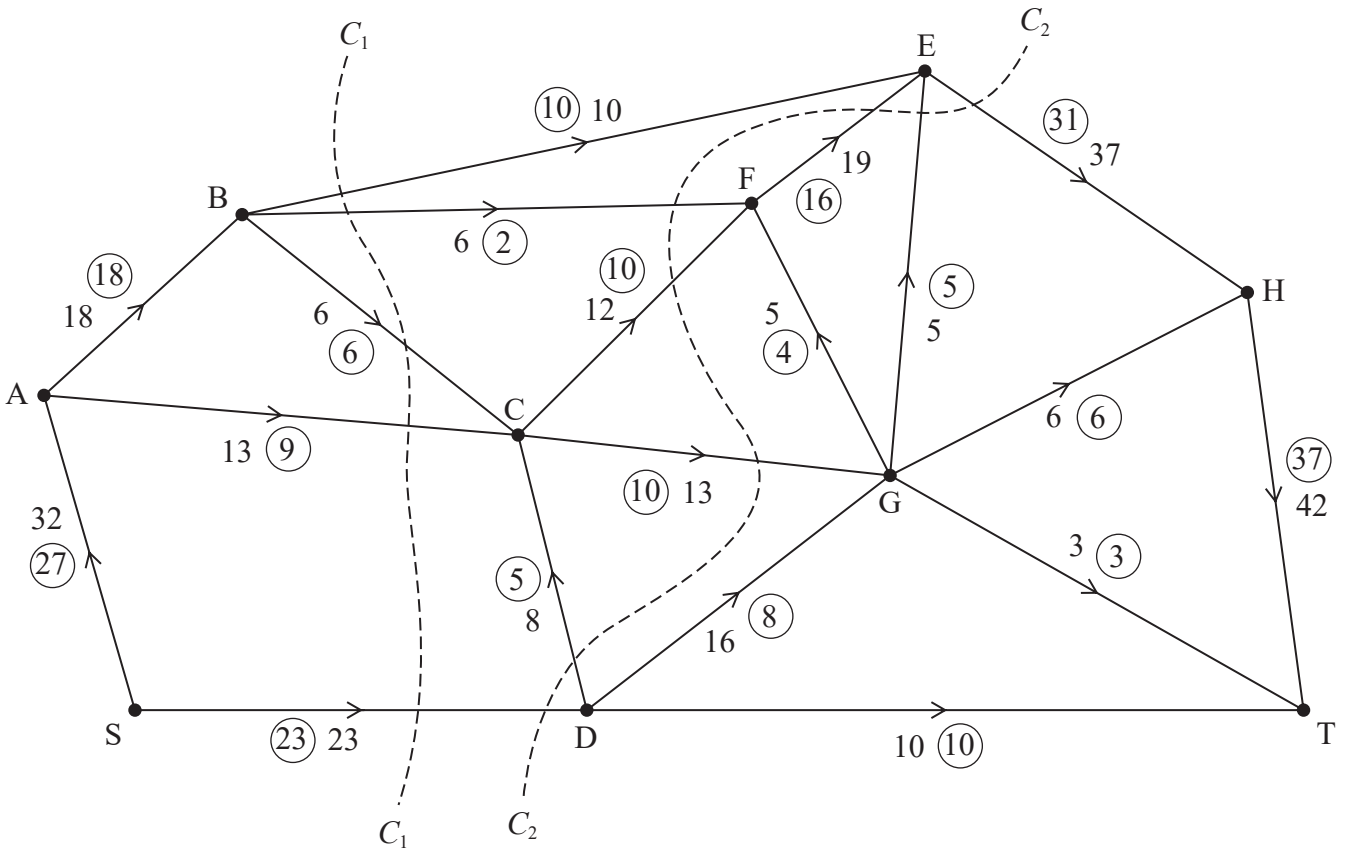
2.

Figure 1

Question 2 continued
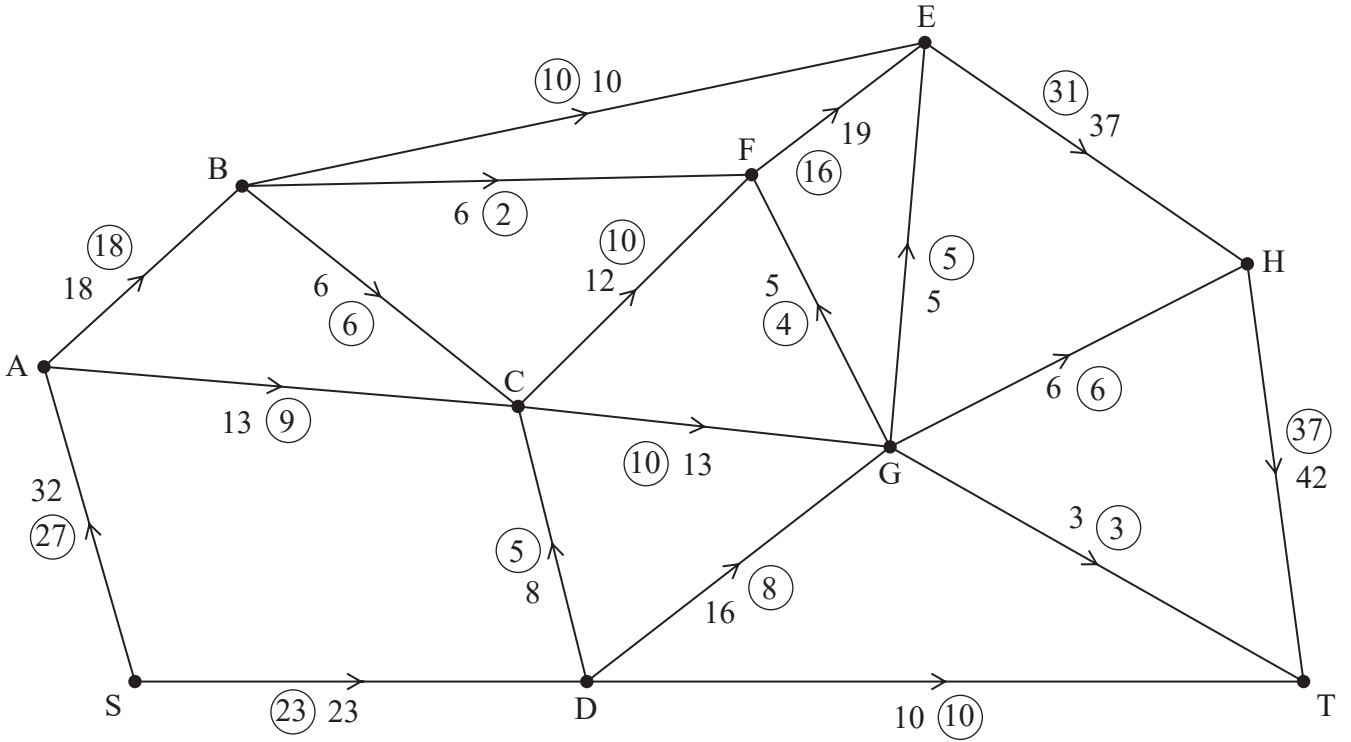
(Total for Question 2 is 9 marks)

3.

		June	
		Option X	Option Y
Terry	Option A	1	4
	Option B	–2	6
	Option C	–1	5
	Option D	8	–4

Question 3 continued

Question 3 continued

(Total for Question 3 is 14 marks)

4.

Question 4 continued

(Total for Question 4 is 10 marks)

TOTAL FOR DECISION MATHEMATICS 2 IS 40 MARKS

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