# Pearson Edexcel Level 3 GCE

# Further Mathematics

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

Thursday 17 May 2018 – Afternoon

Paper Reference
**8FM0-28**

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

**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).
- **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.
- Answers should be given to three significant figures unless otherwise stated.

## 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 to be assigned to four tasks, P, Q, R and S. Each worker must be assigned to exactly one task and each task must be done by only one worker. The time, in hours, that each worker takes to complete each task is shown in the table below.

| | P | Q | R | S |
|---|---|---|---|---|
| A | 7.5 | 3.5 | 8 | 9.5 |
| B | 5 | 2 | 7 | 7.5 |
| C | 4 | 3.5 | 3.5 | 8 |
| D | 6 | 5 | 3.5 | 4 |

Reducing rows first, use the Hungarian algorithm to obtain an allocation which minimises the total time. You must explain your method and show the table after each stage.

**(Total for Question 1 is 5 marks)**

**2.** (a) Explain what the term ‘zero-sum game’ means.

**(1)**

Two teams, A and B, are to face each other as part of a quiz.

There will be several rounds to the quiz with 10 points available in each round.

For each round, the two teams will each choose a team member and these two people will compete against each other until all 10 points have been awarded. The number of points that Team A can expect to gain in each round is shown in the table below.

| | | Team B | | |
|---|---|---|---|---|
| | | Paul | Qaasim | Rashid |
| Team A | Mischa | 5 | 6 | 3 |
| | Noel | 4 | 1 | 7 |
| | Olive | 4 | 5 | 8 |

The teams are each trying to maximise their number of points.

(b) State the number of points that Team B will expect to gain each round if Team A chooses Noel and Team B chooses Rashid.

**(1)**

(c) Explain why subtracting 5 from each value in the table will model this situation as a zero-sum game.

**(1)**

(d) (i) Find the play-safe strategies for the zero-sum game.

(ii) Explain how you know that the game is not stable.

**(4)**

At the last minute, Olive becomes unavailable for selection by Team A.
Team A decides to choose its player for each round so that the probability of choosing Mischa is $p$ and the probability of choosing Noel is $1 - p$.

(e) Use a graphical method to find the optimal value of $p$ for Team A and hence find the best strategy for Team A.

**(6)**

For this value of $p$,

(f) (i) find the expected number of points awarded, per round, to Team A,

(ii) find the expected number of points awarded, per round, to Team B.

**(2)**

**(Total for Question 2 is 15 marks)**

**3.**

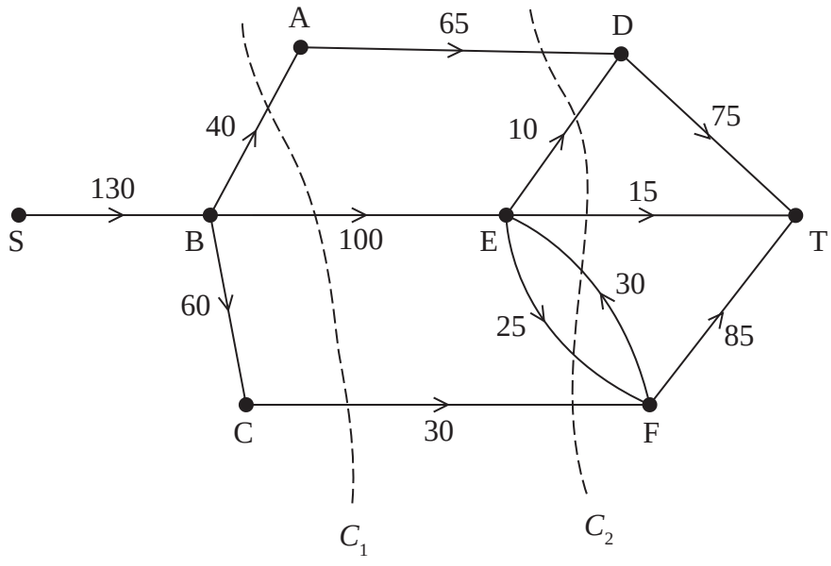


**Figure 1**

Figure 1 models the flow of fluid through a system of pipes from a source, S, to a sink, T. The weights on the arcs show the capacities of the corresponding pipes in litres per minute. Two cuts $C_1$ and $C_2$ are shown.

(a) Find the capacity of

(i) cut $C_1$

(ii) cut $C_2$

**(2)**

(b) Using only the capacities of cuts $C_1$ and $C_2$ state what can be deduced about the maximum possible flow through the system.

**(1)**

(c) On Diagram 1 in the answer book, show how a flow of 120 litres per minute from S to T can be achieved. You do not need to apply the labelling procedure to find this flow.

**(2)**

(d) Prove that 120 litres per minute is the maximum possible flow through the system.

**(2)**

A new pipe is planned from S to A. Let the capacity of this pipe be $x$ litres per minute.

(e) Find, in terms of $x$ where necessary, the maximum possible flow through the new system.

**(3)**

**(Total for Question 3 is 10 marks)**

**4.** A village has an expected population growth rate (birth rate minus death rate) of $r$% per year. In addition, $N$ people are expected to move into the village each year. The expected population of the village is modelled by

$$u_{n+1} = 1.02u_n + 50,$$

where $u_n$ is the expected population of the village $n$ years from now.

(a) State

(i) the value of $r$,

(ii) the value of $N$.

**(2)**

Given that the population 1 year from now is expected to be 560

(b) solve the recurrence relation for $u_n$

**(5)**

(c) Hence determine, using algebra, the number of years from now when the model predicts that the population of the village will first be greater than 3000

**(3)**

**(Total for Question 4 is 10 marks)**

**TOTAL FOR DECISION MATHEMATICS 2 IS 40 MARKS**

**END**