Pearson Edexcel

Mark Scheme (Results)

Summer 2025

Pearson Edexcel GCE

In AS Further Mathematics (8FM0)

Paper 28 Decision Mathematics 2

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 40.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

5. Where a candidate has made multiple responses and indicates which response they wish to submit, examiners should mark this response.
   If there are several attempts at a question which have not been crossed out, examiners should mark the final answer which is the answer that is the most complete.

6. Ignore wrong working or incorrect statements following a correct answer.

7. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

Question	Scheme	Marks	AOs
1(a)	Subtract each entry from a constant, e.g. 50. Replace the two empty cells with a large number. e.g. 100.	**B1** **B1**	1.1a 3.5c
		(2)	
(b)	e.g. $\begin{bmatrix} & J & K & L & M & N \\ A & 12 & 17 & 10 & 15 & 18 \\ B & 24 & 26 & 23 & 25 & 27 \\ C & 17 & 21 & 100 & 20 & 23 \\ D & 14 & 100 & 9 & 13 & 17 \\ E & 18 & 23 & 19 & 21 & 25 \end{bmatrix}$	**B1**	1.1b
	Reduce each row by its minimum element and then in the revised matrix reduce each column by its minimum element.	**B1**	2.4
	Reducing rows and columns gives e.g. $\begin{bmatrix} & J & K & L & M & N \\ A & 2 & 4 & 0 & 3 & 4 \\ B & 1 & 0 & 0 & 0 & 0 \\ C & 0 & 1 & 83 & 1 & 2 \\ D & 5 & 88 & 0 & 2 & 4 \\ E & 0 & 2 & 1 & 1 & 3 \end{bmatrix}$	**M1**	1.1b
	Minimum of 3 lines required to cover zeros, hence solution is not optimal (augment by 1). e.g. $\begin{bmatrix} & J & K & L & M & N \\ A & 2 & 3 & 0 & 2 & 3 \\ B & 2 & 0 & 1 & 0 & 0 \\ C & 0 & 0 & 83 & 0 & 1 \\ D & 5 & 87 & 0 & 1 & 3 \\ E & 0 & 1 & 1 & 0 & 2 \end{bmatrix}$	**M1**	1.1b
	Minimum of 4 lines required to cover zeros, hence solution is not optimal (augment by 1).		

	e.g. $\begin{array}{c\|ccccc} & J & K & L & M & N \\ \hline A & 1 & 2 & 0 & 1 & 2 \\ B & 2 & 0 & 2 & 0 & 0 \\ C & 0 & 0 & 84 & 0 & 1 \\ D & 4 & 86 & 0 & 0 & 2 \\ E & 0 & 1 & 2 & 0 & 2 \end{array}$ 5 lines required to cover zeros, hence solution is optimal. Maximum profit is £161	**M1** **dB1** **A1**	1.1b 2.4 2.2a
		(7)	
			(9 marks)

Notes

a1B1	Correct statement.
a2B1	Correct statement. (Note the statements must be in the correct order so subtraction followed by large values – if order reversed B1 B0)
b1B1	Mark awarded when both steps complete (subtraction, replace blank cells with values > 41).
b2B1	Correct statement regarding row and column reduction. (If given in detail: Reduce row A by 10, reduce row B by 23, reduce row C by 17, reduce row D by 9, reduce row E by 18. No reduction in column J, reduce column K by 3. No reduction in column L, reduce column M by 2, reduce column N by 4.)
b1M1	Simplifying the initial matrix by reducing rows and then columns (condone one slip/error)
b2M1	Develop an improved solution – need to see one double covered +e; one uncovered –e; and one single covered unchanged. 3 lines needed to 4 lines needed.
b3M1	Develop an improved solution – need to see one double covered +e; one uncovered –e; and one single covered unchanged. 4 lines needed to 5 lines (so getting optimal table).
b3dB1	Correct statement regarding the minimum number of lines to cover zeros. (dependent on previous M mark)
b1A1	CSO on final table (so must have all previous marks in this part) + deduction of the correct total profit.

Special Case – Minimisation Max a) B1 B0 b) B0 B1 M1 M0 M1 B1 A0 5/9

	J	K	L	M	N
A	38	33	40	35	32
B	26	24	27	25	23
C	33	29	100	30	27
D	36	100	41	37	33
E	32	27	31	29	25

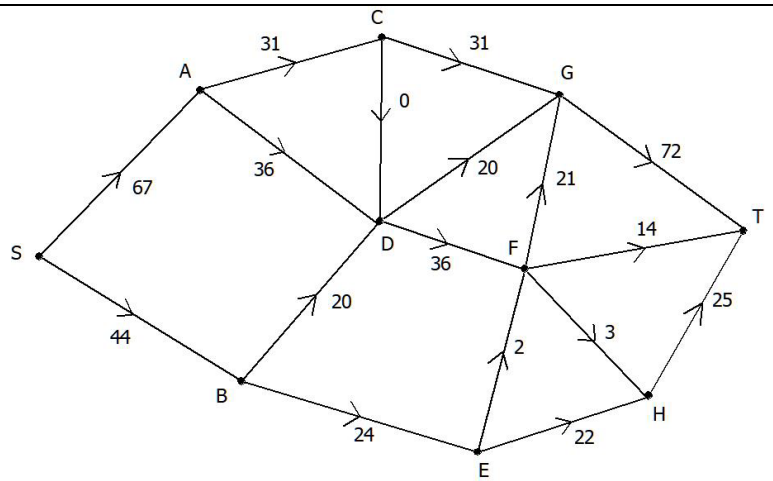
	J	K	L	M	N
A	6	1	8	3	0
B	3	1	4	2	0
C	6	2	73	3	0
D	3	67	8	4	0
E	7	2	6	4	0

e.g.

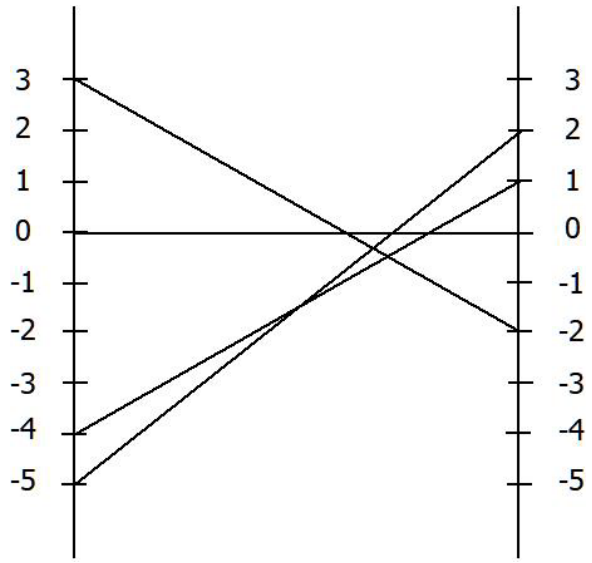
	J	K	L	M	N
A	3	0	4	1	0
B	0	0	0	0	0
C	3	1	69	1	0
D	0	66	4	2	0
E	4	1	2	2	0

e.g.

	J	K	L	M	N
A	3	0	3	0	0
B	1	1	0	0	1
C	3	1	68	0	0
D	0	66	3	1	0
E	4	1	1	1	0

Question	Scheme	Marks	AOs
2(a)	On every arc actual flow cannot exceed capacity. Total flow into a vertex equals total flow out of the vertex for all vertices apart from the source and the sink.	**B1** **B1**	1.2 1.2
		(2)	
(b)	AC, BD, BE, DG, EF, FG, FT	**B1**	1.1b
		(1)	
(c)(i)	C_1= (31 + 45 + 20 + 6 + 25 =) 127	**B1**	1.1b
(c)(ii)	C_2 = (80 + 8 + 45 + 48 =) 181	**B1**	1.1b
		(2)	
(d)	SADFEHT	**B1**	1.1b
		(1)	
(e)		**M1** **A1**	1.1b 1.1b
		(2)	
(f)	Use of max-flow min-cut theorem Identifies cut through, AC, DC, DG, DF, BE or AC, CD, DG, FG, FT, HT capacity = 111 Value of flow =111 Therefore flow is maximal.	**M1** **A1** **A1**	2.1 3.1a 2.2a
		(3)	
			(11 marks)

Notes	
a1B1	Either condition.
a2B1	Both conditions (condone no mention of source and sink).
b1B1	CAO
ci1B1	CAO
cii1B1	CAO
d1B1	A correct flow-augmenting route.
e1M1	All arcs labelled with flows, condone two errors. Condone capacity as well (if clearly distinguished) for this mark
e1A1	Correct numbers labelled on all arcs (one number per arc)
f1M1	Construct argument based on max-flow min-cut theorem so attempt to find a cut through saturated arcs (either stated or drawn).
f1A1	Use appropriate process for finding minimum cut, with cut and value correct.
f2A1	Correct deduction that flow is maximal. Must state value of the flow and see all 4 words max flow min cut and conclusion

Question	Scheme	Marks	AOs
3(a)(i)	Row minima: -2, -5, -3 maximum is -2 Column maxima: 1, 3, 2 minimum is 1 Layla's play-safe is play P and Mohsin's play-safe is play X.	**M1** **A1**	1.1b 1.1b
(ii)	The game is not stable because Row(maximin) (-2) ≠ Column(minimax) (1)	**B1**	2.4
		(3)	
(b)(i)	If Mohsin plays X, Layla's expected pay-off $= 0.5\times 1 + 0.5\times(-4) = -1.5$ If Mohsin plays Y, Layla's expected pay-off $= 0.5\times(-2) + 0.5\times 3 = 0.5$ If Mohsin plays Z, Layla's expected pay-off $= 0.5\times 2 + 0.5\times(-5) = -1.5$	**B1**	1.1b
		(1)	
(b)(ii)	Let Layla play P with probability p and play Q with probability $(1-p)$ If Mohsin plays X, Layla's expected win $= p - 4(1-p) = 5p - 4$ If Mohsin plays Y, Layla's expected win $= -2p + 3(1-p) = -5p + 3$ If Mohsin plays Z, Layla's expected win $= 2p - 5(1-p) = 7p - 5$  $-5p + 3 = 5p - 4 \Rightarrow p = \frac{7}{10}$ Layla should play P with probability 7/10 and play Q with probability 3/10	**B1** **M1** **A1** **M1** **A1** **A1** **A1ft**	3.3 1.1b 1.1b 1.1b 1.1b 1.1b 3.2a
		(7)	
			(11 marks)

Notes	
aiM1	Finding row minimums and column maximums - condone one error.
aiA1	Correct play-safes stated for both players (P and X not values)
aiiB1	Row maximin (-2) ≠ column minimax (1) (must be clearly identified)
bi1B1	Correct calculations, allow one slip.
bii1B1	Defining variable p
bii1M1	Setting up three expressions in terms of p
bii 1A1	All three expressions correct. (must be fully simplified)
bii 2M1	Axes correct, at least one line correctly drawn for their expressions. Horizontally the graph must be drawn between 0 and 1 only
bii 2A1	Correct graph.
bii 3A1	Using the graph to obtain the correct probability expressions leading to the correct value of p
bii4A1ft	Interpret their value of p in the context of the question.

Question	Scheme	Marks	AOs
4(a)	Simplify to $u_{n+1} = -\frac{1}{2}u_n + \frac{3}{4}n - \frac{5}{4}$		
	(aux equation $m + \frac{1}{2} = 0$ =>) complementary function is		
	$A\left(-\frac{1}{2}\right)^n$	B1	2.1
	Try $u_n = an + b$		
	$4\left(a(n+1)+b\right) + 2(an+b) = 3n-5$ and by comparing linear and constant terms gives	M1	1.1b
	$4a + 2a = 3$		
	$4a + 4b + 2b = -5$		
	$a = \frac{1}{2}$ and $b = -\frac{7}{6}$	A1	1.1b
	$u_n = A\left(-\frac{1}{2}\right)^n + \frac{n}{2} - \frac{7}{6}$	A1ft	1.1b
	$u_1 = -2 \Rightarrow -2 = A\left(-\frac{1}{2}\right) + \frac{1}{2} - \frac{7}{6}$	M1	3.4
	$A = \frac{8}{3}, u_n = \frac{8}{3}\left(-\frac{1}{2}\right)^n + \frac{n}{2} - \frac{7}{6}$	A1	1.1b
		(6)	
(b)	$u_2 = \frac{2}{3} + 1 - \frac{7}{6}\left(= \frac{1}{2}\right) > 0$		
	e.g Deduce all even terms must be > 0 as first element of sum will always be positive and $\frac{n}{2} > \frac{7}{6}$ for $n \geq 4$	B1	3.1a
	Consider odd terms: $u_3 = 0, u_5 = -\frac{1}{12} + \frac{5}{2} - \frac{7}{6}\left(= \frac{5}{4}\right) > 0$	M1	2.1
	Observe for all subsequent odd terms first negative element of sum is reducing and $\left(\frac{n}{2} - \frac{7}{6}\right)$ is positive increasing, so all subsequent odd terms > 0		
	Hence there is just one negative term u_1	A1	2.2a
		(3)	
			(9 marks)

Notes	
a1B1	CAO
a1M1	Correct linear form for particular solution and substituted into recurrence relation.
a1A1	CAO
a2A1ft	General solution correct or ft their values for a and b and/or C.F.
a1M1	Correct substitution.
a1A1	u_n = fully correct expression .
b1B1	Even terms > 0
b1M1	Odd terms after $u_1 \geq 0$
b1A1	CAO

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