Mark Scheme (Results)

October 2020

Pearson Edexcel GCE Further Mathematics
AS Further Decision 1 Paper 8FM0_27

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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)	Bin 1: 3.7 2.5 1.9 Bin 2: 5.4 2.7 Bin 3: 3.2 3.1 2.0 Bin 4: 2.7 4.2	M1 A1 A1	1.1b 1.1b 1.1b
		(3)	
1(b)	In the worst case the second number must be compared with the first number so 1 comparison, then the third number must be compared with the first and second numbers so 2 comparisons… so, in total there are $1 + 2 + 3 + \ldots + (n - 1)$ comparisons in total	M1	2.1
	$1+2+...+(n-1)=\frac{1}{2}(n-1)n$	A1	2.2a
	$\frac{1}{2}(n-1)n$ so quadratic order	B1	1.1b
		(3)	
			(6 marks)

Notes

(a)

M1: First four items placed correctly (the values in boxes) with at least eight values placed – allow cumulative totals for M1 only

A1: First eight items placed correctly (the values in boxes and underlined) – no repeated values

A1: CSO (so no repeated values)

(b)

M1: Considers the correct worst case and attempts to sum the total number of comparisons in the first $(n - 1)$ comparisons – this mark can be implied by the correct summation

A1: Correct sum evaluation seen or implied from a correct simplified formula together with the correct method for determining the total number of comparisons in the worst case

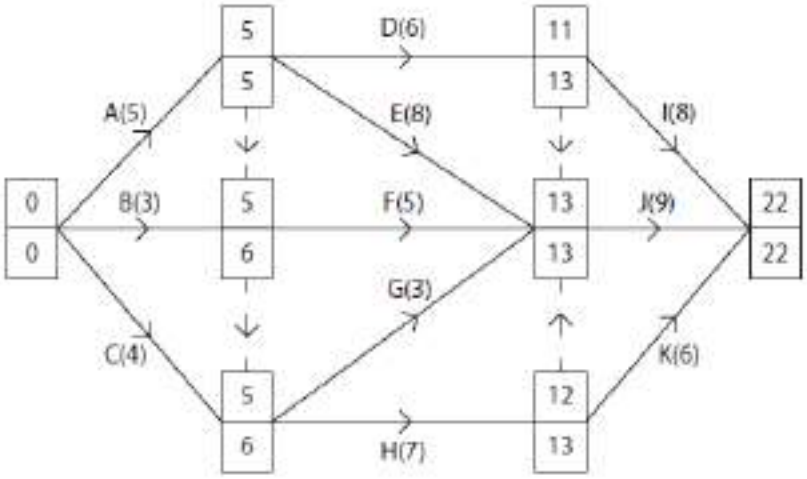
For those candidates who simply state that the total number of comparisons is $\frac{1}{2}n(n-1)$ then M1A0

As a minimum for M1A1 accept (total comparisons =) $\sum_{r=1}^{n-1} r = \frac{1}{2}n(n-1)$ (or considers $1 + 2 + \ldots + (n - 1)$ together with the correct expression for this sum)

B1: Or equivalent e.g. order n^2, $O(n^2)$, etc. (this mark is independent of the previous M and A mark)

<table>
<tr><th>Question</th><th>Scheme</th><th>Marks</th><th>AOs</th></tr>
<tr><td>2(a)</td><td>
<table>
<tr><th>Activity</th><th>Immediately preceding activity</th></tr>
<tr><td>A</td><td>-</td></tr>
<tr><td>B</td><td>-</td></tr>
<tr><td>C</td><td>-</td></tr>
<tr><td>D</td><td>A</td></tr>
</table>
<table>
<tr><th>Activity</th><th>Immediately preceding activity</th></tr>
<tr><td>E</td><td>A</td></tr>
<tr><td>F</td><td>A, B</td></tr>
<tr><td>G</td><td>A, B, C</td></tr>
<tr><td>H</td><td>A, B, C</td></tr>
</table>
<table>
<tr><th>Activity</th><th>Immediately preceding activity</th></tr>
<tr><td>I</td><td>D</td></tr>
<tr><td>J</td><td>D, E, F, G, H</td></tr>
<tr><td>K</td><td>H</td></tr>
</table>
</td><td>B1

B1</td><td>1.1b

1.1b</td></tr>
<tr><td></td><td></td><td>(2)</td><td></td></tr>
<tr><td>2(b)</td><td> 
</td><td>M1

A1

A1</td><td>2.1

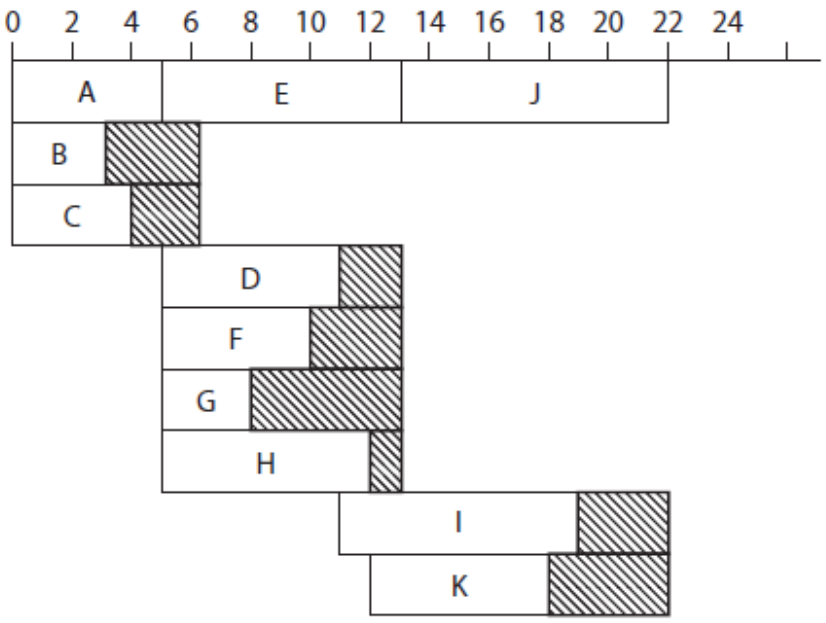
1.1b

1.1b</td></tr>
<tr><td></td><td></td><td>(3)</td><td></td></tr>
<tr><td>2(c)(i)</td><td>Minimum project completion time is 22 hours</td><td>B1ft</td><td>1.1b</td></tr>
<tr><td>2(c)(ii)</td><td>Critical activities are A, E and J</td><td>B1</td><td>1.1b</td></tr>
<tr><td></td><td></td><td>(2)</td><td></td></tr>
<tr><td>2(d)</td><td>H could be delayed by 13 – 5 – 7 = 1 hour</td><td>B1ft</td><td>3.4</td></tr>
<tr><td></td><td></td><td>(1)</td><td></td></tr>
<tr><td>2(e)</td><td>$\frac{5+3+4+...+8+9+6}{22}$

= 2.909... so a lower bound of 3 workers</td><td>M1

A1</td><td>1.1b

2.2a</td></tr>
<tr><td></td><td></td><td>(2)</td><td></td></tr>
</table>

2(f)		**M1** **A1** **A1**	2.1 1.1b 1.1b
		(3)	
2(g)	e.g. between times 5 and 13 activities E, D, F, G and H must all be happening. The total time to complete these five activities is 29 hours and 29/8 > 3 so it is not possible to complete with the lower bound of 3 workers e.g. at time 8.5 activities E, D, F and H must be happening so not possible to complete with only 3 workers	**B1**	3.4
		(1)	
			(14 marks)

Notes

(a)
B1: 5 non-empty rows correct (so any 5 of the rows for activities D to K correct)
B1: All 11 rows correct

(b)
M1: All boxes completed, number generally increasing L to R (condone one "rogue") and decreasing R to L (condone one "rogue")
A1: CAO (all top boxes correct)
A1: CAO (all bottom boxes correct)

(c)(i)
B1ft: CAO following through their completed top boxes from **(b)**

(c)(ii)
B1: CAO (A, E and J only)

(d)
B1ft: Correct calculation for their activity H (from **(b)**) – must see all 3 numbers (so just 13 – 12 = 1 is B0)

(e)

M1: (55 to 73 inclusive) / their duration (their answers to **(b)** and **(c)(i)** must be consistent)

A1: Correct deduction of lower bound from a correct calculation – answer of 3 with no working scores no marks in this part

(f)

M1: At least 9 activities including at least 6 floats

A1: All correct critical activities present and 5 non-critical activities correct

A1: All non-critical activities correct

(g)

B1: Correct reasoning that it is not possible to complete the project with only 3 workers – candidates must refer to both times and activities for this mark (as an indication that they have used **(f)**)

Question	Scheme	Marks	AOs
3(a)	e.g. (each arc contributes 1 to the orders of two nodes, and so) the sum of the orders of all the nodes is equal to twice the number of arcs	B1	1.2
	Which implies that the sum of the orders of all the nodes is even and therefore there must be an even (or zero) number of vertices of odd order hence there cannot be an odd number of vertices of odd order	B1dep	2.4
		(2)	
3(b)	Either $2x+10>3x-2$ or $2x+10>20$	M1	3.1b
	$x < 12$	A1	1.1b
	$x > 5$	A1	1.1b
		(3)	
3(c)	Applies the route inspection algorithm to this non-standard case	M1	3.1b
	C(GF)E + F(GD)H = 37 + 25 = 62	A1	1.1b
	C(G)F + E(FGD)H = 25 + 37 = 62	A1	1.1b
	C(GD)H + EF = 30 + 12 = 42*	A1	1.1b
	$5x + 246 + 42 = 318$	M1dep	3.1a
	$x = 6$	A1	2.2a
		(6)	
			(11 marks)

Notes

(a)

B1: For one of the following points:

- 'Sum of the order/valencies of the nodes/vertices = 2(number of arcs/edges)'
- 'Each arc/edge contributes 1 to the order/valency of two nodes/vertices'
- 'Sum of the order/valencies of the nodes/vertices is even'

But condone for B1 only

- 'sum of the valencies = 2(number of arcs/edges)' **or** 'sum of the nodes/vertices = 2(number of arcs/edges)' **or** 'sum of the orders = 2(number of arcs/edges)
- 'sum of the valencies is even' **or** 'sum of the nodes/edges is even'

B1dep: Stating that 'the sum of the order (or valencies) of the nodes/vertices = 2(number of arcs/edges) therefore the sum of the order (of the nodes/vertices) is even which implies that there must be an even number of nodes/vertices of odd order (or there cannot be an odd number of nodes/vertices of odd order) **OR** each arc/edge contributes 1 to the order of two nodes/vertices therefore the sum of the order (of the nodes/vertices) is even which implies that there must be an even number of nodes/vertices of odd order (or there cannot be an odd number of nodes/vertices of odd order)

So in summary the first B mark should be awarded for a broadly correct statement (but allow bod as shown in the last two bullet-points above) but for both B marks a fully correct explanation must be given without any bod (please note therefore it is not possible to score B0B1). Do not accept non-technical language for nodes/arcs for either B1B0 or B1B1

(b)

M1: Either comparing arc AB with AD or BD with AB – accept any inequality symbol or equals

A1: CAO ($x < 12$)

A1: CAO ($x > 5$)

(c)

M1: Correct three pairings of the required four odd nodes (C, E, F and H)

A1: Any one correct pairing **and** total

A1: Any two correct pairings **and** totals

A1: All three correct pairings **and** totals

M1dep: Setting up an equation using the given values and their smallest pairing (dependent on the previous M mark) – must have three totals from application of route inspection

A1: CAO ($x = 6$)

Question	Scheme	Marks	AOs
4	Line through (0, 12) and (6, 0) is $2x + y = 12$ Line through (0, 12) and (10, 0) is $6x + 5y = 60$ Line through (7, 2) and (9, 8) is $3x – y = 19$	M1	1.1b
	$2x + y \geq 12$	A1	3.4
	$6x + 5y \leq 60$	A1	1.1b
	$3x – y \leq 19$	A1	1.1b
	Solving correct two equations to find V	M1	1.1b
	$V\left(\frac{155}{21}, \frac{22}{7}\right)$	A1	2.2a
	$P = k(5x + 3y)$ and substituting $P = 556$ and their V	M1dep	3.4
	Maximise $P = 60x + 36y$	B1 A1	2.5 2.2a
		(9)	
			(9 marks)

Notes

M1: Correct method for finding the equation of one of the three lines

A1: CAO (with correct inequality sign from shading) $2x + y \geq 12$ (allow a positive multiple but must have integer coefficients)

A1: CAO $6x + 5y \leq 60$ (allow a positive multiple but must have integer coefficients)

A1: CAO $3x – y \leq 19$ (allow a positive multiple but must have integer coefficients)

If A0A0A0 then award A1A0A0 only for one ‘correct’ strict inequality and/or non-integer coefficients e.g. $x + 0.5y > 6$

M1: Attempt to find V by solving the correct pair of simultaneous equations – for this mark either the correct method for solving the simultaneous equations must be seen or if no method seen then this mark can be implied by correctly stating the exact coordinates of V (or correct to at least 3 sf)

A1: Correct deduction of the exact coordinates for V

M1dep: Uses the model to write down a suitable objective and substitutes $P = 556$ and their V into $P = k(5x + 3y)$. Dependent on previous M mark.

Or this mark can be awarded for forming both equations $\frac{155}{21}x + \frac{22}{7}y = 556$ and $3x – 5y = 0$

B1: Maximise (oe) e.g. allow ‘max’ – this mark is independent of all other marks

A1: Correct objective function (this mark cannot be awarded for $5x + 3y$)

Note that the complete LP formulation is

Maximise $P = 60x + 36y$

Subject to $2x + y \geq 12$

$6x + 5y \leq 60$

$3x – y \leq 19$

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