



Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE
In Further Mathematics (8FM0)
Paper 27 Decision Mathematics 1

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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

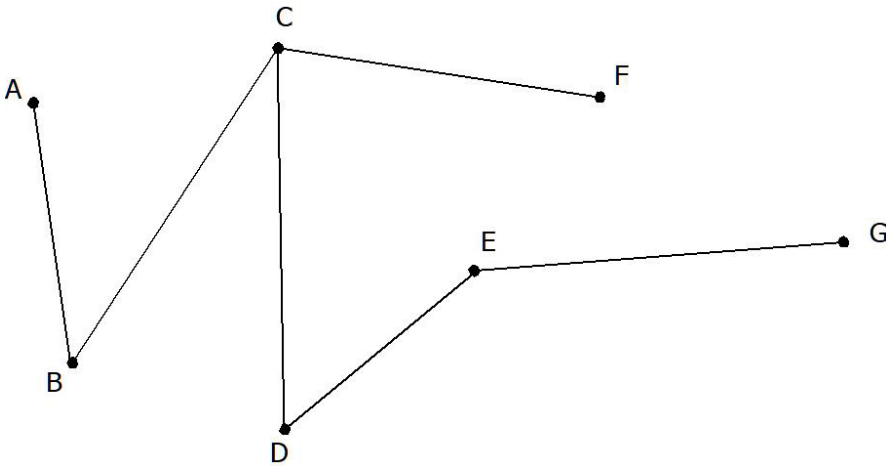
1. The total number of marks for the paper is 40.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the 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 $\checkmark$ 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
 - $\square$ 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.

Qu	Scheme	Marks	AOs
1(a)	middle right		
	55 44 34 59 28 <u>37</u> 41 52 33 42 47	Pivot(s) 37	M1 1.1b
	34 <u>28</u> 33 37 55 44 59 <u>41</u> 52 42 47	28 41	A1 1.1b
	28 34 <u>33</u> 37 41 55 44 59 <u>52</u> 42 47	33 52	
	28 33 34 37 41 44 <u>42</u> 47 52 55 <u>59</u>	(34) 42 59	A1ft 1.1b
	28 33 34 37 41 42 44 <u>47</u> 52 55 59	47 (55)	A1 1.1b
	28 33 34 37 41 42 44 47 52 55 59	(Sort complete)	
	middle left		
	55 44 34 59 28 <u>37</u> 41 52 33 42 47	Pivot(s) 37	
	34 <u>28</u> 33 37 55 44 59 <u>41</u> 52 42 47	28 41	
	28 <u>34</u> 33 37 41 55 44 <u>59</u> 52 42 47	34 59	
	28 33 34 37 41 55 44 <u>52</u> 42 47 59	(33) 52	
	28 33 34 37 41 44 <u>42</u> 47 52 55 59	42 (55)	
	28 33 34 37 41 42 <u>44</u> 47 52 55 59	44	
	28 33 34 37 41 42 44 47 52 55 59	(Sort Complete)	
		(4)	
(b)	DE, CF, CD, reject CE; BC, EG, reject FG; reject BD, AB, (reject AC, reject DG)	M1 A1 A1	1.1b 1.1b 1.1b
		(3)	
(c)(i)		B1	2.2a
	(Total weight =) 230	B1	2.2a
		(2)	
(9 marks)			

Notes for Question 1

a1M1: Quick Sort, pivot, p, chosen (must be choosing middle right or middle left). After the first pass the list must read (values less than the pivot), pivot, (values greater than the pivot). **If choosing one pivot per iteration then M1 only.** This mark can be scored if one number only is either missing or incorrect or an additional number is added to the list.

a1A1: First two passes correct (pivots for third pass need not be chosen)

a2A1ft: Third and fourth passes correct (follow through from their second pass and choice of pivots) (pivot(s) for the fifth pass need not be chosen). After their second pass their list must contain either 10, 11 or 12 numbers (so allow one additional/missing number)

a3A1: cso – if choosing middle right pivots then they must include a fifth pass and if choosing middle left then they must include a sixth pass

SC: If list is sorted into descending order, then award a maximum of M1A1A0A0 (so 2 marks) as in the scheme above even if the list is re-ordered after the sort is complete

b1M1: Kruskal: first three arcs correctly chosen (DE, CF, CD), and arc CE rejected at the correct time. No follow through from an incorrect list. Condone list of weights for this mark only (28, 33, 34 and reject 37)

b1A1: First five arcs correctly chosen (DE, CF, CD, BC, EG), and arc FG rejected at the correct time. Must state the arcs and not the corresponding weights for this mark

b2A1: cso including all rejections correct and at the correct time. We do not need to see the explicit rejection of arcs AC and DG but if these are explicitly rejected then they must be in the correct order. Note that a list of all the arcs in the correct order followed by a list of the arcs in the MST can score full marks

ci1B1: Correct MST drawn

cii1B1: Correct weight

Qu	Scheme	Marks	AOs
2(a)	<pre> graph LR Start(()) -- A --> Node1(()) Node1 -- E --> Node2(()) Node1 -- B --> Node3(()) Node1 -- C --> Node4(()) Node3 -- F --> Node2 Node3 -- F --> Node5(()) Node4 -- D --> Node6(()) Node4 -- G --> Node5 Node6 -- H --> Node7(()) Node5 -- I --> End(()) Node5 -- J --> End Node7 -- K --> End </pre>	M1 A1 A1 A1 A1	1.1b 1.1b 1.1b 1.1b 1.1b
		(5)	
(b)	e.g. Activity E is preceded by activity A only, but activity F is preceded by activity B (and/or C) as well as activity A	B1	2.4
		(1)	
(c)	Activity D as this is the only activity on a path from start to finish of which contains only two activities. All other activities appear on at least one longer path	M1 A1	3.1b 3.4
		(2)	

(8 marks)

Notes for Question 2

Condone lack of, or incorrect, numbered events throughout. 'Dealt with correctly' means that the activity starts from the correct event but need not necessarily finish at the correct event, e.g. 'K dealt with correctly' requires the correct precedences for this activity, i.e. D and H labelled correctly and leading into the same node and K starting from that node but do not consider the end event for K.

Activity on node is M0

If an arc is not labelled, for example, if the arc for activity D is not labelled (but the arc is present) then this will lose the first A mark and the final (CSO) A mark – they can still earn the third A mark on the bod. If two or more arcs are not labelled then mark according to the scheme. Assume that a solid line is an activity which has not been labelled rather than a dummy (even if in the correct place for where a dummy should be)

Ignore incorrect or lack of arrows on the activities for the first four marks only

a1M1: At least eight activities (labelled on arc), one start and at least two dummies placed

a1A1: Activities A, B, C, D, E, G and H dealt with correctly

a2A1: Activity F dealt with correctly and first two dummies & correct arrows dealt with correctly

a3A1: Activities I, J, K and final dummy dealt with correctly.

a4A1: cso All arrows present and correctly placed with one finish and no additional dummies

Please check all arcs carefully for arrows – if there are no arrows on any dummies then M1 only. Note that additional (but unnecessary) 'correct' dummies that still maintain precedence for the network should only be penalised with the final A mark if earned

b1B1: Reference to E depends on A only, while F depends on A and B (and/or C). So must mention activities A, E, F and at least one of B and C

c1M1: cao - Activity D **only** – if more than one activity stated then M0

c1A1: Correct reasoning. Explain that the path/route through D is the only one containing two activities **or** that all other routes/paths have 3 activities. Or mention activities C, H and K **and** that C and H together take 'longer' to finish than D

Qu	Scheme	Marks	AOs
3(a)	A path is a (i) finite sequence of edges, such that (ii) the end vertex of one edge in the sequence is the start vertex of the next, and in which (iii) no vertex appears more than once	B2,1,0	1.2 1.2
		(2)	
(b)	Graph is neither Eulerian nor semi-Eulerian because it has six odd vertices.	B1	2.4
		(1)	
(c)	Shortest path: ABEH	M1 A1 (ABDC) A1(FE) A1ft (GH)	1.1b 1.1b 1.1b 1.1b
		A1	2.2a
		(5)	
(d)	If arc CD included: $AE + GH = 17 + 12 = 29$ $AG + EH = 20 + 5 = 25$ $AH + EG = 22 + 10 = 32$ If arc EG included: $AC + DH = 11 + 17 = 28$ $AD + CH = 10 + 12 = 22^*$ $AH + CD = 22 + 11 = 33$ Track EG with repeated arcs AD, CF, FE, EH Length = $120 + 9 + 22 = 151$ (km)	M1 A1 depM1 A1 A1 A1	3.1b 1.1b 1.1b 1.1b 2.2a 2.2a
		(6)	
(14 marks)			
Notes for Question 3			

a1B1: One of the three points made clearly ('finite, edges', 'end vertex of one edge is the start vertex of the next', 'no vertex appears more than once' – condone 'a vertex cannot appear twice' but not 'a vertex cannot be repeated more than once')

a2B1: All three points made clearly. Candidates who state that a path is a walk in which no vertex appears more than once can score B1B0 only

b1B1: Correct statement (neither) with correct reason. Either states that there are more than two odd nodes **or** does not have exactly zero or two odd nodes **or** that there are six odd nodes. Their argument must be convincing that the graph cannot be Eulerian or semi-Eulerian (e.g. 'the network does not have two odd nodes' is B0). Do not ISW (or BOD) if any incorrect reasoning given

In (c) it is important that all values at each node are checked very carefully – the order of the working values must be correct for the corresponding A mark to be awarded e.g. at H the working values must be 24 22 in that order (so 22 24 is incorrect)

It is also important that the order of labelling is checked carefully. The order of labelling must be a strictly increasing sequence – so 1, 2, 3, 3, 4, ... will be penalised once (see notes below) but 1, 2, 3, 5, 6, ... is fine. Errors in the final values and working values are penalised before errors in the order of labelling

c1M1: A larger value replaced by a smaller value at least twice in the working values at either C, F, G, H

c1A1: All values at A, B, D and C correct and the working values in the correct order

c2A1: All values at F and E correct and working values in the correct order. Penalise order of labelling only once per question. Condone an additional working value of 18 after the 17 at E

c3A1ft: All values in G and H correct on the follow through and the working values in the correct order. To follow through G check that the working values at G follow from the candidate's final values for the nodes that are directly attached to G (which are D and F). For example, **if** correct then the order of labelling of nodes D and F are 3 and 5 respectively so the working values at G should come from D and F in that order. The first working value at G should be their 10 (the Final value at D) + 11 (the weight of the arc DG), the second working value at G should be their 14 (the Final value at F) + 6 (the weight of the arc FG). Repeat the process for H (which will have working values from F, E and G with the order of these nodes determined by the candidate's order of labelling at F, E and G). Condone an additional working value of 32 after the 22 at H

c4A1: cao for shortest path (ABEH)

d1M1: One correct set (either AEGH or ACDH) of three distinct pairings of the correct four odd nodes (so must have AE + GH, AG + EH and AH + EG **or** AC + DH, AD + CH and AH + CD)

d1A1: Any three rows correct including pairings **and** totals, from either set AEGH or set ACDH

d2dM1: All six distinct pairings for nodes AEGH and ACDH – dependent on first M mark

d2A1: All six rows correct including pairings **and** totals

d3A1: cao correct edges clearly stated and not just in their working. **Must** be edges AD, CF, FE, EH **and** clearly selecting track EG

d4A1: cao (151) from correct working – **dependent on first four marks in this part**

Qu	Scheme	Marks	AOs
4(a)	$x + y \leq 14$ $2y - x \leq 12$ $3x - y \leq 15$ $(x \geq 0, y \geq 0)$	M1	3.3
		A1 A1	1.1b 2.5
		(3)	
(b)(i)	Attempts to solve two equations to find optimal vertex	M1	3.4
	$\left(\frac{16}{3}, \frac{26}{3}\right)$	A1	1.1b
(ii)	$P = k(4x + 10y)$	M1	3.1a
	$216 = k\left(4 \times \frac{16}{3} + 10 \times \frac{26}{3}\right)$	ddM1	3.4
	$(P =) 8x + 20y$	A1	2.2a
		(5)	
(c)	6 small (flower pots) and 8 large (flower pots)	B1	3.2a
		(1)	

(9 marks)

Notes for Question 4

a1M1: One correct non-trivial inequality in any form e.g. $x - 2y + 12 \geq 0$. Condone strict inequality. Must be simplified to three terms only but coefficients do not need to be integers
a1A1: Two correct non-trivial inequalities in any form e.g. $x - 2y + 12 \geq 0$. Condone strict inequalities. Must be simplified to three terms only but coefficients do not need to be integers
a2A1: All three non-trivial inequalities correct with three terms and integer coefficients

bi1M1: Attempt to solve their $x + y = 14$ and $2y - x = 12$ (so their line with negative gradient and their line that passes through (0, 6)) simultaneously with at least one equation correct – the correct answer with no working implies this mark

bi1A1: cao $\left(\frac{16}{3}, \frac{26}{3}\right)$ or $\left(5\frac{1}{3}, 8\frac{2}{3}\right)$ - must be exact (allow $x = \dots, y = \dots$) and clearly stated as the optimal vertex if more than one vertex of the FR found

bii1M1: Expression comprising of a constant (unknown) multiple/factor of $2x + 5y$
e.g. $k(4x + 10y)$ - M0 if assuming the objective is $4x + 10y$ or if no k (or equivalent letter)

bii2ddM1: Dependent on both previous M marks. Forming an equation with the expression $k(4x + 10y)$ (or any multiple/factor of this), the 216 and their optimal vertex

bii1A1: cao – accept $8x + 20y$ or this expression equal to any letter but not for e.g. $8x + 20y = 0$ or 216

c1B1: 6 small and 8 large – not for (6, 8) or $x = 6, y = 8$ – must be in context

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