GCE

Further Mathematics B MEI

Y433/01: Modelling with algorithms

A Level

Mark Scheme for June 2025

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training: OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. **Crossed-Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed-out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed-out response where legible.

Rubric Error Responses – Optional Questions
Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM Assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple-Choice Question Responses
When a multiple-choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only one mark per response)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth two or more marks)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space).

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.

7. There is a NR (**No Response**) option. Award NR (No Response):

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g., 'can't do', 'don't know')
   - OR if there is a mark (e.g., a dash, a question mark) which is not an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response: Not applicable in F501
    To determine the level – start at the highest level and work down until you reach the level that matches the answer
    To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. **Annotations**

Annotation	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.

Subject Specific Marking Instructions

a. Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)
- if there is nothing written at all in the answer space and no attempt elsewhere in the script
- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
- OR if there is a mark (e.g. a dash, a question mark, a picture) which isn't an attempt at the question.

Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not always be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

If you are in any doubt whatsoever you should contact your Team Leader.

c. The following types of marks are available.

M

A suitable method has been selected and applied in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using

some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.
A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words “Determine” or “Show that”, or some other indication that the method must be given explicitly.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d. When a part of a question has two or more ‘method’ steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation ‘dep*’ is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be ‘follow through’. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)
We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.
- When a value is given in the paper only accept an answer correct to at least as many significant figures as the given value.
- When a value is not given in the paper accept any answer that agrees with the correct value to 2 s.f. unless a different level of accuracy has been asked for in the question, or the mark scheme specifies an acceptable range.
  NB for Specification A the rubric specifies 3 s.f. as standard, so this statement reads “3 s.f”.

Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
Candidates using a value of 9.80, 9.81 or 10 for g should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

g. Rules for replaced work and multiple attempts:
- If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
- If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
- if a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

h. For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate’s data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors.
If a candidate corrects the misread in a later part, do not continue to follow through. Note that a miscopy of the candidate’s own working is not a misread but an accuracy error.

i. If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold “In this question you must show detailed reasoning”, or the command words “Show” or “Determine”. Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j. If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	AOs	Guidance
1	(a)		Minimise 32AP + 39AQ + 37AR + 29BP + 28BQ + 32BR + 35CP + 36CQ + 39CR + 38DP + 39DQ + 34DR	**B1**	**3.3**	Correct objective + 'Minimise'
			AP + BP + CP + DP = 1 AQ + BQ + CQ + DQ = 1 AR + BR + CR + DR = 1	**B1**	**3.3**	All three constraints that require each task to be completed by at most one worker
			$AP + AQ + AR \leqslant 1$ $BP + BQ + BR \leqslant 1$ $CP + CQ + CR \leqslant 1$ $DP + DQ + DR \leqslant 1$	**M1**	**1.1**	Demonstrating an understanding that not all workers can be allocated a task (e.g. one constraint correct, or four constraints containing an inequality sign rather than 'equals').
				A1	**2.5**	All four correct and no others.
				[4]		
1	(b)		(Worker) C or Casey	**B1** **[1]**	**1.1**	cao
1	(c)		94 (minutes)	**B1** **[1]**	**1.1**	oe (e.g. 1 hr 34 mins)

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AOs</th><th>Guidance</th></tr>
<tr><td>2</td><td>(a)</td><td></td><td>
<table>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>5</td><td>6</td><td>150</td><td>5.5</td><td>-16.375</td></tr>
<tr><td></td><td>5.5</td><td></td><td>5.25</td><td>5.297</td></tr>
<tr><td>5.25</td><td></td><td></td><td>5.375</td><td>-5.287</td></tr>
<tr><td></td><td>5.375</td><td></td><td>5.3125</td><td>0.067</td></tr>
</table>
Or
<table>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>5</td><td>6</td><td>150</td><td>$\frac{11}{2}$</td><td>-16.375</td></tr>
<tr><td></td><td>$\frac{11}{2}$</td><td></td><td>$\frac{21}{4}$</td><td>5.297</td></tr>
<tr><td>$\frac{21}{4}$</td><td></td><td></td><td>$\frac{43}{8}$</td><td>-5.287</td></tr>
<tr><td></td><td>$\frac{43}{8}$</td><td></td><td>$\frac{85}{16}$</td><td>0.067</td></tr>
</table>
Output = 5.31</td><td>M1

A1

A1

A1

[4]</td><td>2.1

1.1

1.1

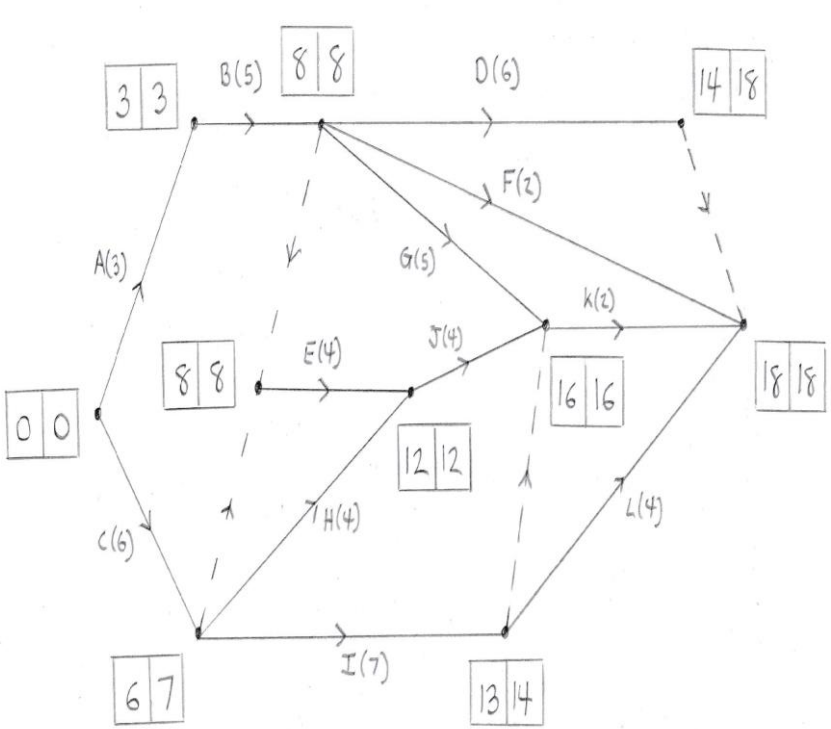
2.2a</td><td>Correct initial values for D & E and B updated to 5.5 or $\frac{11}{2}$

A updated to 5.25 and B updated to 5.375. Third E value achieving awrt -5.287.

Correct fourth iteration (so achieving awrt 0.067 as the fourth E value and exact value of D given)

Completely correct application of the given algorithm and correct output to exactly 2 decimal places</td></tr>
<tr><td>2</td><td>(b)</td><td></td><td>The cube root of 1500 is not between A (5) and B (6).
or
One value needs to be a greater than the cube root of 1500 and the other needs to be a value that is smaller than the cube root of 1500.</td><td>B1

[1]</td><td>2.3</td><td></td></tr>
</table>

Question			Answer	Marks	AOs	Guidance
3	(a)					
	(b)	(i)	e.g  (dummy after F – working values 10,18)	M1 <

Question			Answer	Marks	AOs	Guidance
	(c)		e.g.  	**M1** **A1** **A1** **[3]**	**3.1b** **1.1** **1.1**	At least 10 activities placed with a single worker, no activity finishing after their completion time for the entire project (as stated in part **(b)(ii)**) 9 activities dealt with correctly - correct predecessors and activity length cao D, F & G following B E following B & C H & I following C J following E & H K following G & I L following I
	(d)		e.g. Between time 12 and 13 four activities J, D, G and I must be taking place. e.g. One worker is required for the critical activities. Only activity C can start before time 6 therefore the remaining 6 activities H, D, F, G, I and L which have a total duration of 28 cannot be scheduled into the remaining time of 24 hours $(2 \times (18 - 6))$ if only two further people are available.	**B1** **[1]**	**2.4**	Any valid reason why only 3 workers is not possible

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AOs</th><th>Guidance</th></tr>
<tr><td>4</td><td>(a)</td><td></td><td>k must be non-negative as otherwise $x = y = z = 0$ would not be a (basic) feasible solution (which is required if the simplex method is to be used to solve the problem)</td><td>B1

[1]</td><td>3.5b</td><td>An indication that (0, 0, 0) must be a solution to the LP if simplex is to be used
(accept origin)</td></tr>
<tr><td>4</td><td>(b)</td><td></td><td>Initial tableau:

<table>
<tr><th>P</th><th>x</th><th>y</th><th>z</th><th>s_1</th><th>s_2</th><th>s_3</th><th>RHS</th></tr>
<tr><td>1</td><td>-2</td><td>-1</td><td>-4</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>-3</td><td>1</td><td>1</td><td>0</td><td>0</td><td>40</td></tr>
<tr><td>0</td><td>3</td><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td><td>56</td></tr>
<tr><td>0</td><td>-2</td><td>4</td><td>1</td><td>0</td><td>0</td><td>1</td><td>k</td></tr>
</table>
</td><td>M1

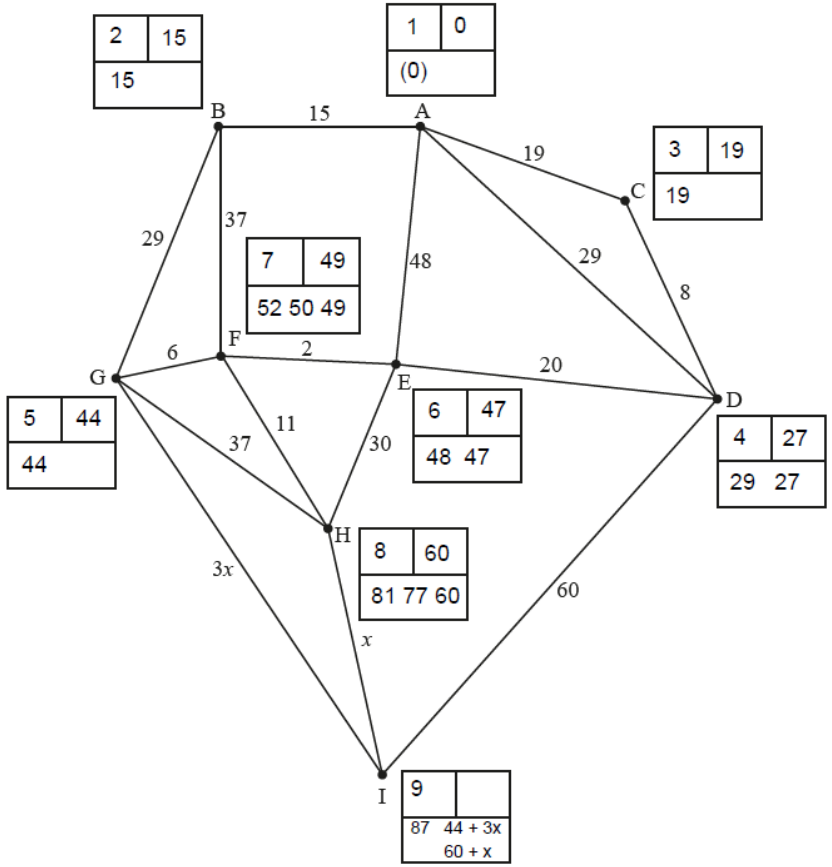
A1

[2]</td><td>3.3

1.1</td><td>Two rows correct

cao</td></tr>
</table>

Question			Answer	Marks	AOs	Guidance
4	(c)		1st iteration: P | x | y | z | s_1 | s_2 | s_3 | RHS 1 | 2 | -13 | 0 | 4 | 0 | 0 | 160 0 | 1 | -3 | 1 | 1 | 0 | 0 | 40 0 | 2 | 4 | 0 | -1 | 1 | 0 | 16 0 | -3 | 7 | 0 | -1 | 0 | 1 | $k-40$	**M1***	**3.4**	Pivoting on the column z – their pivot row must be unaltered (RHS 40 or k) and z is basic
				A1	**1.1**	Any two columns from x, y, s_1 and RHS correct or one correct non-pivot row for their iteration
				A1	**1.1**	cao for their first iteration
			2nd iteration: P | x | y | z | s_1 | s_2 | s_3 | RHS 1 | $\frac{17}{2}$ | 0 | 0 | $\frac{3}{4}$ | $\frac{13}{4}$ | 0 | 212 0 | $\frac{5}{2}$ | 0 | 1 | $\frac{1}{4}$ | $\frac{3}{4}$ | 0 | 52 0 | $\frac{1}{2}$ | 1 | 0 | $-\frac{1}{4}$ | $\frac{1}{4}$ | 0 | 4 0 | $-\frac{13}{2}$ | 0 | 0 | $\frac{3}{4}$ | $-\frac{7}{4}$ | 1 | $k-68$	**M1dep***	**3.1a**	Correct pivot chosen (and corresponding pivot row correct) from the y column (following through their 1st iteration)
				A1	**1.1**	cao for second iteration
			$\boldsymbol{k_1 = 68}$	**A1FT**	**3.2a**	Follow through their 2nd iteration provided no negative values in objective row
			$P = 212,\ \ x = 0,\ \ y = 4,\ \ z = 52$	**A1** **[7]**	**2.2a**	

Question			Answer	Marks	AOs	Guidance
5	(a)					
				M1	1.2	Correct working values at D or E
				A1	1.1a	Correct working values
				A1	1.1a	Labels (ignore label at I)
				A1	1.1	Order of Labelling
			ACDI with corresponding length 87	B1	1.1	Can be given in any order
			ABGI with corresponding length $44 + 3x$	B1	1.1	
			ACDEFHI with corresponding length $60 + x$	B1	1.1	
				[7]		

Question			Answer	Marks	AOs	Guidance
5	(b)	(i)	Prim's: AB, AC, CD, DE, EF, FG, FH, HI	**M1**	**1.1**	First three arcs (or four nodes) chosen in the correct order
				A1	**1.1**	cao - must be stated as arcs.
				[2]		
5	(b)	(ii)	Weight of MST is $81 + x$	**B1**	**1.1**	
				[1]		
5	(c)		$60 + x < 44 + 3x$ or $60 + x < 87$	**M1**	**3.1a**	Weight of shortest path from A to I via F compared correctly to either of the other two weights found in part **(a)**
			$44 + 3x < 81 + x$	**M1**	**1.1**	Weight of shortest path from A to I via G compared correctly to the weight of their MST
			$8 < x < 18.5 \Rightarrow 9 \leqslant x \leqslant 18$ or $\Rightarrow 8 < x \leqslant 18$	**A1**	**3.2a**	
				[3]		

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AOs</th><th>Guidance</th></tr>
<tr><td>6</td><td>(a)</td><td></td><td>$2x + 4y + z = 23$</td><td>B1
[1]</td><td>3.4</td><td></td></tr>
<tr><td>6</td><td>(b)</td><td></td><td>$Q = a_1 + a_2$
where $3x + y + z - s_2 + a_1 = 23$
and $2x + 4y + z - s_3 + a_2 = 23$

$Q = 23 - 3x - y - z + s_2 + 23 - 2x - 4y - z + s_3$
$\Rightarrow Q = 46 - 5x - 5y - 2z + s_2 + s_3$

<table><tr><td>Q</td><td>P</td><td>x</td><td>y</td><td>z</td><td>s_1</td><td>s_2</td><td>s_3</td><td>s_4</td><td>a_1</td><td>a_2</td><td>RHS</td></tr><tr><td>1</td><td>0</td><td>5</td><td>5</td><td>2</td><td>0</td><td>-1</td><td>-1</td><td>0</td><td>0</td><td>0</td><td>46</td></tr></table></td><td>M1

A1

[2]</td><td>2.2a

2.1</td><td>Correctly indicates that $Q = a_1 + a_2$and attempt to find equation with two equations involving the artificial variables.
May be implied from correct tableau.

cao</td></tr>
<tr><td>6</td><td>(c)</td><td></td><td>$P = 2x + y + 3(23 - 2x - 4y)$

$P = -4x - 11y + 69$

The constant is irrelevant (for maximisation purposes).
Maximising $-(4x + 11y)$ is equivalent to minimising $4x + 11y$</td><td>M1

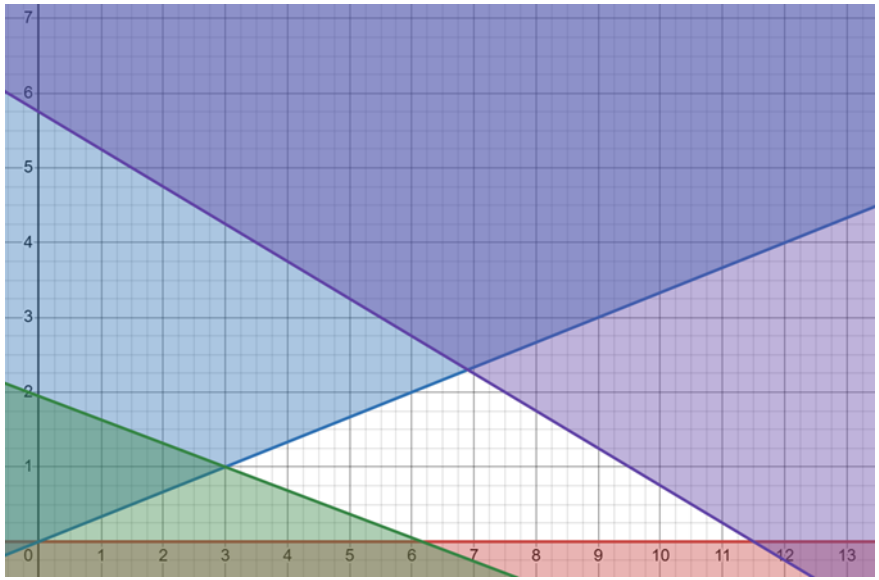
A1

A1

[3]</td><td>3.1a

1.1

2.4</td><td>Eliminate z from the objective using the equality constraint $2x + 4y + z = 23$</td></tr>
</table>

Question			Answer	Marks	AOs	Guidance
6	(d)		Either $2x - 3y + 4(23 - 2x - 4y) \leqslant 55$ or $3x + y + 23 - 2x - 4y \geqslant 23$ or $23 - 2x - 4y \geqslant 0$	**M1**	**3.1a**	$z = 23 - 2x - 4y$ substituted into at least one constraint
			$6x + 19y \geqslant 37$ $x \geqslant 3y$ $2x + 4y \leqslant 23$ $(x \geqslant 0,\ y \geqslant 0)$	**A1** **A1**	**1.1** **3.4**	For any one correct constraint o.e. For all three correct constraints o.e.
				**M1** **M1** **A1**	**1.1** **1.1** **1.1**	Any two lines correct Any three of the four lines that create the feasible region correct All four lines correct and corresponding correct feasible region – feasible region must be labelled in some distinctive way
			$P = 46$ $x = 3, \quad y = 1, \quad z = 13$	**A1** **A1** **[8]**	**3.2a** **2.2a**	

Need to get in touch?

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