

Mathematics

Advanced Subsidiary GCE

Unit **4736**: Decision Mathematics 1

Mark Scheme for June 2013

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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1. Annotations

Annotation in scoris	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
Highlighting	
Other abbreviations	Meaning
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

2. Subject-specific Marking Instructions for GCE Mathematics (OCR) Decision strand

- a. Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

- 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 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, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) 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, eg 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

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.

- 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, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

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. Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g. Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

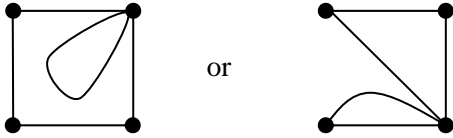
h. For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

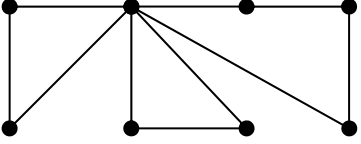
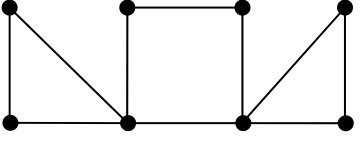
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

*** Ensure that there you given evidence of having checked every page, including blank pages of additional objects (eg put a tick on a blank page) ***

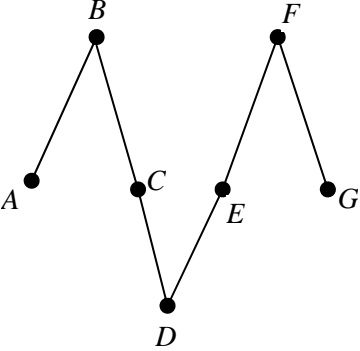
*** When a part has not achieved partial marks show M, A, B marks or use highlighting and ticks/crosses/^ to indicate correct work /where errors occurred ***

Question		Answer	Marks	
1	(i)	Original list: 24 57 9 31 16 4 Compare 24 and 57 or <u>24</u> <u>57</u> 9 31 16 4 Compare 57 and 9, swap 24 <u>57</u> <u>9</u> 31 16 4 Compare 57 and 31, swap 24 9 <u>57</u> <u>31</u> 16 4 Compare 57 and 16, swap 24 9 31 <u>57</u> <u>16</u> 4 Compare 57 and 4, swap 24 9 31 16 <u>57</u> 4 Resulting list: 24 9 31 16 4 57	M1 A1 [2]	Bubble the wrong way, shuttle, etc \Rightarrow 0 marks in (i) and (ii) Values compared and values swapped written down or indicated using, for example, underlining and/or arrows. Must be <u>immediately obvious</u> which values are being compared. List correct (written) after one pass (cao) (List without showing which values are compared and which are swapped \Rightarrow M0, A0)
1	(ii)	9 24 16 4 31 57 9 16 4 24 31 57	B1 B1 [2]	cao, allow 9 24 16 4 31 57, but not just 9 24 16 4 cao, allow 9 16 4 24 31 57, but not just 9 16 4 Penalise each new miscopy of their own work (here or from (i)) by 1 mark (up to a maximum of 2)
1	(iii)	4, 3, 2, 1, 1	M1 A1 [2]	Five non-negative integer values (being at maximum 5, 4, 3, 2, 1 respectively) cao (ignore 11 if seen as total)

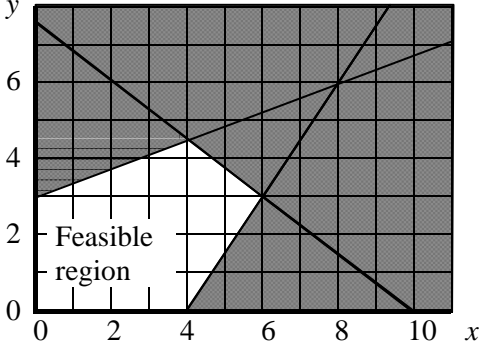
Question			Answer	Marks	
2	(i)	(a)		B1 [1]	A connected graph with three vertices of order 2 and one of order 4
2	(i)	(b)	<p>Examples of answers that get 2 marks:</p> <p>The <u>only</u> simply connected graph with four vertices and five arcs is the complete graph K_4 with one arc removed (or a diagram of this case), but this is not Eulerian <u>since</u> (two) odd vertices.</p> <p>Simple so vertex orders are at most 3 (and connected so vertex orders are at least 1), Eulerian so each vertex order is even; hence each vertex has order 2, but that only gives 4 arcs.</p> <p>Sum of vertex orders = 10 and graph is Eulerian, so vertex orders must be 2, 2, 2, 4. But then graph cannot be simple.</p> <p>Sum of vertex orders = 10 and Eulerian so a vertex of order 4, this will result in <u>either</u> a vertex connected to itself <u>or</u> repeat a connection between two nodes, so not simple</p> <p>Allow drawing <u>both</u> diagrams from (a) (and no others) <u>and</u> saying ‘not simple’</p>	M1 A1 [2]	<p>Examples of valid partial reasoning for M1 A0</p> <p>drawing or describing the graph K_4 with one arc removed, or saying 2, 2, 3, 3 (and no other possibility)</p> <p>drawing a graph with four vertices each of order 2 and then talking about there being no way to add in the fifth arc</p> <p>saying that there would have to be a vertex of order 4 (ie 2, 2, 2, 4)</p> <p>saying ‘it cannot be simple as the fifth arc will result in <u>either</u> a vertex connected to itself <u>or</u> repeat a connection between two nodes’</p> <p>drawing <u>both</u> diagrams from (a) (and no others) but not saying ‘not simple’</p> <p>‘Eulerian so all nodes even so a loop so not simple’ \Rightarrow M0 ‘more arcs than vertices’ or ‘arcs > $n-1$’ \Rightarrow M0 ‘odd number of arcs’ is irrelevant</p> <p>A reasoned argument that addresses both ‘sum of vertex orders is 10 and graph is Eulerian’ and ‘graph is simple’</p>

2	(ii)	(a)	Sum of vertex orders is twice the number of arcs	B1 [1]	$2 \times 10 = 20$ Allow 'each arc has two ends' but not 'each arc connects two nodes' (could form a loop) (Note: 10 and 20 are given in the question)
2	(ii)	(b)	Minimum = 2 Maximum = 6 eg 	B1 M1 A1 [3]	Min 2 (not implied from eg 2, 4 6 or from $2 \times 8 = 16$) Max 6 (not implied from eg 2, 4 6 or from $6 \times 8 = 48$) A <u>simple</u> connected graph with eight vertices, seven of order 2 and one of order 6 (and no others) Note: any odd vertices \Rightarrow A0 Mark attempt on printed nodes, unless otherwise indicated BOD dashed arcs erased, otherwise mark what you see
2	(ii)	(c)	eg 	B1 [1]	A <u>simple</u> connected graph with eight vertices, six of order 2 and two of order 4 (and no others) Note: any odd vertices \Rightarrow B0 Mark attempt on printed nodes, unless otherwise indicated BOD dashed arcs erased, otherwise mark what you see

<p>3 (i)</p>		<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Step</th> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>F</th> <th>G</th> <th>M</th> </tr> </thead> <tbody> <tr><td>1</td><td>30</td><td>18</td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td>2</td><td></td><td></td><td>12</td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td>5</td><td></td><td></td><td></td><td>30</td><td>18</td><td></td><td></td><td></td></tr> <tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td>12</td><td></td><td></td></tr> <tr><td>9</td><td></td><td></td><td></td><td>12</td><td></td><td></td><td></td><td></td></tr> <tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td>-6</td><td></td><td></td></tr> <tr><td>7</td><td></td><td></td><td></td><td>18</td><td>12</td><td></td><td></td><td></td></tr> <tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td>6</td><td></td><td></td></tr> <tr><td>9</td><td></td><td></td><td></td><td>6</td><td></td><td></td><td></td><td></td></tr> <tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td>-6</td><td></td><td></td></tr> <tr><td>7</td><td></td><td></td><td></td><td>12</td><td>6</td><td></td><td></td><td></td></tr> <tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td>6</td><td></td><td></td></tr> <tr><td>9</td><td></td><td></td><td></td><td>6</td><td></td><td></td><td></td><td></td></tr> <tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td>0</td><td></td><td></td></tr> <tr><td>8</td><td></td><td></td><td></td><td></td><td></td><td>6</td><td></td><td></td></tr> <tr><td>11</td><td></td><td></td><td></td><td></td><td></td><td></td><td>5</td><td></td></tr> <tr><td>12</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>90</td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </tbody> </table> <p>Output: 6, 90</p>	Step	A	B	C	D	E	F	G	M	1	30	18							2			12						5				30	18				6						12			9				12					6						-6			7				18	12				6						6			9				6					6						-6			7				12	6				6						6			9				6					6						0			8						6			11							5		12								90																			<p>*** Scroll down to check spare table and tick page *** (spare table may be used for part (iii)) If an entry is blank use the most recent value</p> <p>B1 $D = 30, E = 18, F = 12$ Initial values of D, E, F</p> <p>B1 $D = 18, E = 12, F = 6$ At (third) use of step 6</p> <p>B1 $D = 12, E = 6, F = 6$ At some later update</p> <p>B1 $D = 6, E = 6, F = 0$ When F changes to 0</p> <p>Condone steps merged together or errors in Step column</p> <p>For a misread (MR) of input values mark the first two and last two marks only (note: F is hcf and M is lcm of inputs)</p> <p>B1 6 written as output (print) or (if not) as final F in table, cao B1 90 written as output (print) or (if not) as final M in table, cao [6]</p>
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<p>3 (ii)</p>		<p>Initial values of D and E are same as in (i) then as in (i) to give output 6, 90</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Step</th> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>F</th> <th>G</th> <th>M</th> </tr> </thead> <tbody> <tr><td>1</td><td>18</td><td>30</td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td>2</td><td></td><td></td><td>-12</td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td>3</td><td></td><td></td><td></td><td>30</td><td>18</td><td></td><td></td><td></td></tr> <tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </tbody> </table>	Step	A	B	C	D	E	F	G	M	1	18	30							2			-12						3				30	18				6																											<p>M1 Initial values $D = 30, E = 18$ (in table or stated) A1 Same output (F and M) as in (i) or ‘then as before’ (stated or shown in table)</p> <p>A misread (MR) will lose the A mark</p> <p>(final value of G is 3 - this does not need to be seen, but do not penalise if it is given as 5, left blank or is wrong)</p> <p>[2]</p>																																																																																																																					
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<p>3 (iii)</p>		<p>$F = 4$ $M = 24$</p>	<p>B1 Answers need to be seen here (may see working in spare table, ignore this unless it is labelled as being (iii)) B1 [2]</p>																																																																																																																																																																																				

<p>4 (i)</p>	<p> $CD = 5$ $DE = 7$ $AB = 8$ $CE = 8$ $FG = 9$ $BC = 10$ $AC = 11$ $EF = 12$ $BF = 14$ $EG = 15$ $AD = 16$ $DG = 18$ $BE = 20$ $AF = 23$ $BG = 24$ $CF = 24$ </p> <p style="text-align: center;">  </p> <p style="text-align: center;">Weight = 51</p> <p> $A - B - C - D - E - F - G - F - B - A$ </p>	<p> B1 Do not condone answers in wrong spaces, unless labelled B1 Correct tree drawn (if return via $GFBA$ is also shown then B0) B1 Evidence <u>in list</u> of CE and AC not being chosen and everything else above AC being chosen (ignore what happens with EF and everything below there) B1 51 (cao) (must be seen, not implied from part of a calculation) B1 This closed route, or in reverse, starting at any vertex (must be written) No credit for any other route, even if it is shorter [4] </p>
<p>4 (ii)</p>	<p> Replace CD and DE with $CE \Rightarrow 51 - 5 - 7 + 8 = 47$ $A - B - C - E - F - G - D - A$ </p>	<p> B1 47 or 'their 51' - 4 (do not need to see working) B1 This cycle, or in reverse, starting at any vertex (not as two parts) [2] </p>
<p>4 (iii)</p>	<p> $A - B - C - D - E - F - G$ then stalls and cannot return to A $B - A - C - D - E - F - G - B$ Swap F and G to get $B - A - C - D - E - G - F - B$ = 69 km </p>	<p> M1 $A - B - C - D - E - F - G$ (may go beyond G) (must be written) A1 'stalls', 'stuck', 'fails', 'cannot return to A', 'node(s) visited twice', or similar. Do not allow 'it forms a mini-cycle / loop' M1 $B - A - C - D - E - F$ (must be written) A1 Complete cycle correct and in this order M1 This cycle, or in reverse, starting at any vertex (must be written) A1 69 (condone no units) [6] </p>

<p>5 (i)</p>		<p>$A - B - F - G$</p>	<p>B1 M1 A1 B1 B1 B1 [5]</p>	<p>$B = 8, C = 11$ (temp or perm) and no others (no 18 at C) <u>Temp</u> label 23 at F (ignore any extras or omission of 22 here) Condone 23 crossed out if consistent (eg with E or G) (condone errors in other temp labels) All <u>permanent</u> labels correct (A may be blank, but others must be written as perm) Order of labelling correct for <u>their</u> permanent labels (use best temp if no perm shown), with A as 1 Condone boxes swapped, provided consistent $A - B - F - G$ (cao) written or very easily seen on diagram Allow AB, BF, FG</p>
<p>5 (ii)</p>	<p>$\left(\frac{1400}{7}\right)^2 \times 2.25 \text{ seconds} = 200^2 \times 2.25 \text{ seconds} = 90\,000 \text{ seconds}$ $= 1500 \text{ minutes} = 25 \text{ hours}$</p>	<p>$11 + x + 15 \leq 31$ ($x = \text{new length of } CE$) or $11 + 8 + 15 = 34$ $\Rightarrow x \leq 5$ 34 - 'their 31' (from i) \Rightarrow (at least) 3 km shorter 34 - 31 = 3</p>	<p>M1 A1 [2]</p>	<p>A valid method for time in seconds (or minutes or hours) eg $k(1400)^2$ with $k = 2.25/49$ or equivalent (as a fraction) 25 (cao) (25 www \Rightarrow M1 A1)</p>
<p>5 (iii)</p>	<p>With the arcs AC and CE removed, odd nodes are A, B, C and F $AB = 8$ $AC = 18$ $AF = 22$ $CF = 24$ $BF = 14$ $BC = 10$ 32 32 32 Total weight of arcs in network = 205 The warden must travel 205 + 32 = 237 km</p>	<p>$11 + x + 15 \leq 31$ ($x = \text{new length of } CE$) or $11 + 8 + 15 = 34$ $\Rightarrow x \leq 5$ 34 - 'their 31' (from i) \Rightarrow (at least) 3 km shorter 34 - 31 = 3</p>	<p>M1 A1 [2]</p>	<p>Method may be implied from answer 3 www, but watch out for answer 3 from wrong working Allow $x < 5$ or $x = 5$, (CE) would become 5 (less than 5) 3 as answer (cao, www), condone '3 less' without 'at least', units not reqd. ISW if answer 3 www is followed by 4</p>
<p>5 (iv)</p>	<p>With the arcs AC and CE removed, odd nodes are A, B, C and F $AB = 8$ $AC = 18$ $AF = 22$ $CF = 24$ $BF = 14$ $BC = 10$ 32 32 32 Total weight of arcs in network = 205 The warden must travel 205 + 32 = 237 km</p>	<p>$11 + x + 15 \leq 31$ ($x = \text{new length of } CE$) or $11 + 8 + 15 = 34$ $\Rightarrow x \leq 5$ 34 - 'their 31' (from i) \Rightarrow (at least) 3 km shorter 34 - 31 = 3</p>	<p>B1 M1 A1 B1 M1 A1 [6]</p>	<p>A, B, C, F (may be implied from working) Any one correct <u>pairing</u> with weights <u>or</u> total All three correct (with weights <u>or</u> totals) $CF=20, AC=11 \Rightarrow A0$ 205 or $224 - 11 - 8$ or equivalent (<u>seen</u> in working) ('Their 205' or (200 to 210) or 224) + 'their 32' (min total weight of their claimed pairings), or implied from 237 www 237 (cao), condone no units</p>

<p>6 (i)</p>		<p>Ignore profit line(s) if shown</p> <p>M1 Line through (4, 4.5) and (6, 3) (± 0.2 on each coordinate)</p> <p>M1 Line through (4, 0) and (6, 3) (± 0.2 on each coordinate)</p> <p>M1 Line through (0, 3) and (4, 4.5) (± 0.2 on each coordinate)</p> <p>A1 Shading correct, feasible region (FR) need not be labelled (this A mark is dependent on all three M marks) (need not show shading out $x < 0, y < 0$)</p> <p>*** Scroll down to check spare copy and tick it as seen ***</p> <p>[4] [Visually impaired candidates have tolerance ± 0.5 throughout]</p>																								
<p>6 (ii)</p>	<p>(4, 0), (6, 3), (4, 4.5) and (0, 3)</p> <table border="1" data-bbox="356 778 781 887"> <tr> <td>x</td> <td>4</td> <td>6</td> <td>4</td> <td>0</td> </tr> <tr> <td>y</td> <td>0</td> <td>3</td> <td>4.5</td> <td>3</td> </tr> <tr> <td>P</td> <td>20</td> <td>54</td> <td>56</td> <td>24</td> </tr> </table> <p>Optimal when $x = 4, y = 4.5, P = 56$</p>	x	4	6	4	0	y	0	3	4.5	3	P	20	54	56	24	<p>M1 Any two vertices of their FR (other than origin), as coordinates or equivalent (from their graph to within ± 0.2) Or two of the correct vertices (new start)</p> <p>A1 These four coordinates correct, ignore any extra points</p> <p>M1 (6, 3) \rightarrow 54 and (4, 4.5) \rightarrow 56 (both seen, not implied) or $P = 5x + 8y$ calculated for two of their vertices with $x > 0, y > 0$</p> <p>A1 (4, 4.5) indicated (eg arrowed) and (4, 4.5) \rightarrow 56 seen (cao)</p> <p>[4]</p>									
x	4	6	4	0																						
y	0	3	4.5	3																						
P	20	54	56	24																						
<p>6 (iii)</p>	<table border="1" data-bbox="356 1026 887 1134"> <tr> <td>x</td> <td>0</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> <td>6</td> </tr> <tr> <td>y</td> <td>3</td> <td>3</td> <td>3</td> <td>4</td> <td>4</td> <td>3</td> <td>3</td> </tr> <tr> <td>P</td> <td>24</td> <td>29</td> <td>34</td> <td>47</td> <td>52</td> <td>49</td> <td>54</td> </tr> </table> <p>Optimal when $x = 6, y = 3$</p>	x	0	1	2	3	4	5	6	y	3	3	3	4	4	3	3	P	24	29	34	47	52	49	54	<p>M1 Four (x, max y) pairs, in any form, (follow through their FR)</p> <p>A1 All 7 pairs correct, and no extras (cao, not ft)</p> <p>M1 Calculating $P = 5x + 8y$ correctly for at least three of <u>their</u> listed integer-valued points (not implied from answer (6, 3))</p> <p>A1 (6, 3) written down, in any form (cao)</p> <p>[4]</p>
x	0	1	2	3	4	5	6																			
y	3	3	3	4	4	3	3																			
P	24	29	34	47	52	49	54																			
<p>6 (iv)</p>	<p>So that a slack variable can be added to form an equality or RHS (value) needs to be non-negative</p>	<p>B1 Allow 'constraints must be \leq' or 'third constraint was \geq' Do not allow 'positive' for 'non-negative'</p> <p>[1]</p>																								

6	(v)	<table border="1" data-bbox="353 199 887 379"> <thead> <tr> <th>P</th> <th>x</th> <th>y</th> <th>s</th> <th>t</th> <th>u</th> <th>RHS</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>-5</td> <td>-8</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>3</td> <td>-2</td> <td>1</td> <td>0</td> <td>0</td> <td>12</td> </tr> <tr> <td>0</td> <td>3</td> <td>4</td> <td>0</td> <td>1</td> <td>0</td> <td>30</td> </tr> <tr> <td>0</td> <td>-3</td> <td>8</td> <td>0</td> <td>0</td> <td>1</td> <td>24</td> </tr> </tbody> </table>	P	x	y	s	t	u	RHS	1	-5	-8	0	0	0	0	0	3	-2	1	0	0	12	0	3	4	0	1	0	30	0	-3	8	0	0	1	24		<p>Order of rows and columns may be changed, need not be labelled</p> <p>M1 4 × 7 table of values with the three constraint rows correct (including P column, although columns need not be labelled)</p> <p>A1 Objective row correct</p> <p>Assume blanks mean zero</p> <p>[2] May credit initial tableau seen in (vi) if no response seen in (v)</p>																																														
P	x	y	s	t	u	RHS																																																																															
1	-5	-8	0	0	0	0																																																																															
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0	3	4	0	1	0	30																																																																															
0	-3	8	0	0	1	24																																																																															
6	(vi)	<p>Least non-negative ratio in y column is $24 \div 8$ Pivot on 8 in row 4 of y column Row 4 (pr) = $r4 \div 8$ Row 1 = $r1 + 8pr$ or $r1 + r4$ Row 2 = $r2 + 2pr$ $r2 + (1/4) r4$ Row 3 = $r3 - 4pr$ $r3 - (1/2) r4$</p> <p>Using decimals or fractions</p> <table border="1" data-bbox="353 753 1081 930"> <thead> <tr> <th>P</th> <th>x</th> <th>y</th> <th>s</th> <th>t</th> <th>u</th> <th>RHS</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>-8</td> <td></td> <td>0</td> <td>0</td> <td>1</td> <td>24</td> </tr> <tr> <td>0</td> <td>2.25</td> <td>(9/4)</td> <td>0</td> <td>1</td> <td>0.25</td> <td>(1/4)</td> <td>18</td> </tr> <tr> <td>0</td> <td>4.5</td> <td>(9/2)</td> <td>0</td> <td>0</td> <td>-0.5</td> <td>(-1/2)</td> <td>18</td> </tr> <tr> <td>0</td> <td>-0.375</td> <td>(-3/8)</td> <td>1</td> <td>0</td> <td>0.125</td> <td>(1/8)</td> <td>3</td> </tr> </tbody> </table> <p>$x = 0, y = 3$ and $P = 24$</p> <p>Using decimals or fractions</p> <table border="1" data-bbox="353 1034 1155 1211"> <thead> <tr> <th>P</th> <th>x</th> <th>y</th> <th>s</th> <th>t</th> <th>u</th> <th>RHS</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>0</td> <td>0</td> <td>1.778</td> <td>(16/9)</td> <td>0.111</td> <td>(1/9)</td> <td>56</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> <td>1</td> <td>-0.5</td> <td>(-1/2)</td> <td>0.5</td> <td>(1/2)</td> <td>9</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>0</td> <td>0.222</td> <td>(2/9)</td> <td>-0.111</td> <td>(-1/9)</td> <td>4</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>0</td> <td>0.083</td> <td>(1/12)</td> <td>0.083</td> <td>(1/12)</td> <td>4.5 (9/2)</td> </tr> </tbody> </table>	P	x	y	s	t	u	RHS	1	-8		0	0	1	24	0	2.25	(9/4)	0	1	0.25	(1/4)	18	0	4.5	(9/2)	0	0	-0.5	(-1/2)	18	0	-0.375	(-3/8)	1	0	0.125	(1/8)	3	P	x	y	s	t	u	RHS	1	0	0	0	1.778	(16/9)	0.111	(1/9)	56	0	0	0	1	-0.5	(-1/2)	0.5	(1/2)	9	0	1	0	0	0.222	(2/9)	-0.111	(-1/9)	4	0	0	1	0	0.083	(1/12)	0.083	(1/12)	4.5 (9/2)		<p>(Some working may be seen in (v), mark this on scroll down)</p> <p>B1 Correct pivot choice for y col of their tableau, (may be implied)</p> <p>B1 Correct methods for rows for their positive pivot choice (condone pivot row method not shown, accept reasonable abbreviations, eg $+8pr$ or $a+8h$ but not just $+8$) ft their tableau</p> <p>Condone ($r4$) for (pr) provided consistent</p> <p>M1 An augmented tableau in which P value has increased and all entries in RHS column are ≥ 0 (values need not be correct, but do need written values, not blanks) Condone omission of P column or errors elsewhere in tableau</p> <p>A1 Values of x, y, P written, ft their tableau for non-negative x, y and positive P</p> <p>M1 An augmented tableau in which P value has increased and all entries in RHS column are ≥ 0 (values need not be correct, but do need written values, not blanks) Condone omission of P column or errors elsewhere in tableau</p> <p>A1 Basis columns correspond to $P = 56, x = 4, y = 4.5$ and a slack variable = 9 (values do not need to be written down) (tableau does not need to be correct but does need to correspond to (4, 4.5), 56 and 9 from basis cols with 0's and 1 in them)</p> <p>* Scroll down to check second page (colour scanned) and attached (v) *</p> <p>[6]</p>
P	x	y	s	t	u	RHS																																																																															
1	-8		0	0	1	24																																																																															
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OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
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CB1 2EU

OCR Customer Contact Centre

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