



**GCE**

# **Mathematics**

Advanced GCE

Unit **4736**: Decision Mathematics 1

## **Mark Scheme for January 2012**

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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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## Annotations and abbreviations

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 in mark scheme	Meaning
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
soi	Seen or implied
www	Without wrong working

**Subject-specific Marking Instructions for GCE Mathematics 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.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg 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.

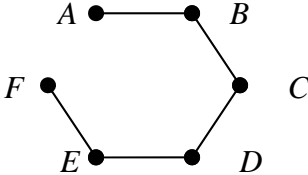
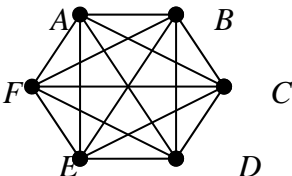
- d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep \*' is used to indicate that a particular mark is dependent on an earlier, 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, 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 (eg 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.

Remember to check for additional objects

Question	Answer	Marks	Guidance
1	<p>Original list: 3 6 2 6 5 7 1 4 9 (C S)</p> <p>After 1<sup>st</sup> pass: <u>6 3</u> 2 6 5 7 1 4 9 (1 1)</p> <p>After 2<sup>nd</sup> pass: <u>6 3 2</u> 6 5 7 1 4 9 (1 0)</p> <p>After 3<sup>rd</sup> pass: <u>6 6 3 2</u> 5 7 1 4 9 (3 2)</p> <p>After 4<sup>th</sup> pass: <u>6 6 5 3 2</u> 7 1 4 9 (3 2)</p> <p>After 5<sup>th</sup> pass: <u>7 6 6 5 3 2</u> 1 4 9 (5 5)</p> <p>After 6<sup>th</sup> pass: <u>7 6 6 5 3 2 1</u> 4 9 (1 0)</p> <p>After 7<sup>th</sup> pass: <u>7 6 6 5 4 3 2 1</u> 9 (4 3)</p> <p>After 8<sup>th</sup> pass: <u>9 7 6 6 5 4 3 2 1</u> (8 8)</p> <p>Total = 8 passes</p> <p>26 comparisons and 21 swaps</p>	<p>M1</p> <p>M1</p> <p>A1</p> <p>B1</p> <p>B1</p> <p>B1</p> <p>Tally marks are NOT acceptable as final answers</p>	<p>If all working shown, accept any consistent interpretation of where each pass ends, eg a blank row between passes</p> <p>Correct list after 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> passes (pass 2 may need to be implied, then what is labelled as 2<sup>nd</sup> pass will be 3<sup>rd</sup>)</p> <p>Correct list after 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup> and 7<sup>th</sup> passes (pass 6 may need to be implied, and pass numbers will be out by 1 or 2)</p> <p>Final order correct after 8 passes shown (pass 2 or 6 missing ⇒ M1,M1,A0)</p> <p>8 (cao) explicitly written down (not just from last pass in working being pass 8)</p> <p>26 comparisons (cao)</p> <p>21 swaps (cao)</p> <p>Do not accept starting at end of list and working to the left, sorting into increasing order or use of bubble sort</p> <p>Working may be written horizontally or vertically</p> <p>Condone omission of or errors in elements not yet considered</p> <p>Some candidates use   to partition</p> <p>Condone omission of or errors in elements not yet considered</p> <p>Dependent on <u>both</u> method marks</p> <p>Misread in original list ⇒ M1,M1,A0</p> <p>Miscopying own work is not a misread</p> <p>May be shown in a summary after the passes were carried out</p> <p>8 passes, from any sorting method</p> <p>Allow without identification as comparisons</p> <p>Increasing shuttle gives 20 ⇒ SC B1</p> <p>Allow without identification as swaps (if not identified, take the larger value as comps and the smaller as swaps)</p> <p>Increasing shuttle gives 14 ⇒ SC B1</p> <p>MR in original list can FT for B marks provided C and S working seen</p>

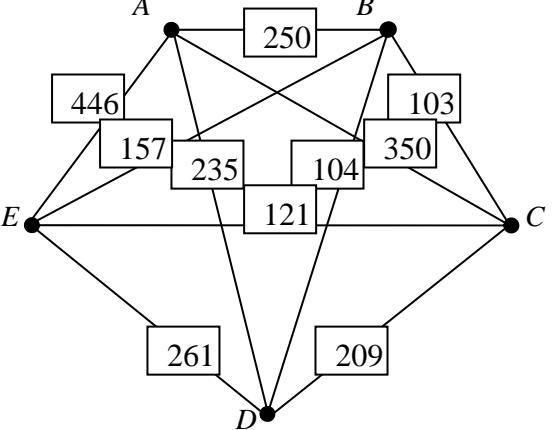
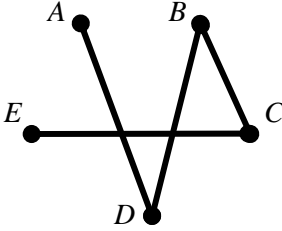
Question		Answer	Marks	Guidance
2	(i)	eg 	B1	Any tree drawn on the six vertices  Must have 6 vertices, 5 arcs and be simply connected  May need to BOD erased lines (if consistent with answer 5)
		5	B1	5 (cao)
2	(ii)		B1	Complete graph drawn on the six vertices  Must have 6 vertices each of order 5 Arcs may be straight or curved  Check diagram carefully
		15	B1	15 (cao)
2	(iii)	12  Eulerian so each vertex has even order, hence maximum order at each vertex is 4 $4 \times 6 = 24 \Rightarrow 12$ arcs	B1	12 (cao) seen  Even if from $2 \times 6 = 12$
		Eulerian so each vertex has even order, hence maximum order at each vertex is 4 $4 \times 6 = 24 \Rightarrow 12$ arcs	B1	Statement that each vertex has order 4, or clearly implied from a <u>description</u> of removing three arcs from the complete graph ('take 3 arcs away')  A diagram on its own (without some explanation) is not enough 'Each vertex must be even' is not enough Calculations alone are not enough
2	(iv)	<u>Exactly</u> two odd order vertices (or equivalent)   eg FACEBAD	B1	F and D are the <u>only</u> odd nodes F and D have order 1 <u>and</u> all the other nodes have even orders List all orders <u>and</u> identify F and D Condone 'two odd nodes, F and D'
		eg FACEBAD	B1	FACEBAD FABECAD DABECAF DACEBAF  Any one of these four possible answers

Question		Answer	Marks	Guidance																
3	(i)	<div style="text-align: center;"> <table style="margin: auto;"> <tr> <td style="text-align: center;"><i>A</i></td> <td style="text-align: center;"><i>B</i></td> <td style="text-align: center;"><i>D</i></td> <td style="text-align: center;"><i>F</i></td> </tr> <tr> <td style="border: 1px solid black; padding: 2px;">1   0</td> <td style="border: 1px solid black; padding: 2px;">3   5</td> <td style="border: 1px solid black; padding: 2px;">5   9</td> <td style="border: 1px solid black; padding: 2px;">6   13</td> </tr> <tr> <td style="border: 1px solid black; padding: 2px;"> </td> <td style="border: 1px solid black; padding: 2px;">6   5</td> <td style="border: 1px solid black; padding: 2px;">9</td> <td style="border: 1px solid black; padding: 2px;">14   13</td> </tr> </table>   <table style="margin: auto;"> <tr> <td style="border: 1px solid black; padding: 2px;">2   3</td> <td style="border: 1px solid black; padding: 2px;">4   8</td> </tr> <tr> <td style="border: 1px solid black; padding: 2px;">3</td> <td style="border: 1px solid black; padding: 2px;">8</td> </tr> </table> <p style="text-align: center;"><i>C</i>                      <i>E</i></p> <p>Route <i>A-C-B-D-F</i></p> <p>Weight 13</p> </div>	<i>A</i>	<i>B</i>	<i>D</i>	<i>F</i>	1   0	3   5	5   9	6   13		6   5	9	14   13	2   3	4   8	3	8	<p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>B1</p> <p>B1</p>	<p>Correct updating at <i>B</i> (6 and 5 in lower box, and nothing else)</p> <p>All temporary labels correct, not implied from permanent labels. No extra values. No updating at <i>D, E</i></p> <p>All permanent labels correct. Not dependent on previous method mark</p> <p>All order of labelling values correct Dependent on M mark for permanent labels</p> <p><i>ACBDF</i> (cao) or in reverse</p> <p>13 (cao)</p> <p>nb Scroll down to check second copy</p> <p>May be consistently interchanged with order of labelling boxes. Condone blank at <i>A</i> Condone all reduced by 1 Not ft Written down, not just on network</p> <p>Written down, not just on network</p>
<i>A</i>	<i>B</i>	<i>D</i>	<i>F</i>																	
1   0	3   5	5   9	6   13																	
	6   5	9	14   13																	
2   3	4   8																			
3	8																			
3	(ii)	<p>Total weight of all arcs in network = 38 Only odd nodes are <i>C</i> and <i>D</i> Repeat shortest path from <i>C</i> to <i>D</i> weight = 6 Weight = 38 + 6 = 44</p>	<p>B1</p> <p>B1</p> <p>B1</p>	<p>38 seen</p> <p><u>Both</u> <i>CD</i> (or <i>C-B-D</i>) <u>and</u> 6 seen</p> <p>44</p> <p>Or 6 + their 38 (calculated)</p>																
3	(iii)	<p>Now need to make <i>C</i> and <i>D</i> even and also make <i>A</i> and <i>F</i> odd</p> <table style="margin: auto;"> <tr> <td style="text-align: center;"><i>AF</i> = 13</td> <td style="text-align: center;"><i>AC</i> = 3</td> <td style="text-align: center;"><i>AD</i> = 9</td> </tr> <tr> <td style="text-align: center;"><i>CD</i> = <u>6</u></td> <td style="text-align: center;"><i>DF</i> = <u>4</u></td> <td style="text-align: center;"><i>CF</i> = <u>10</u></td> </tr> <tr> <td style="text-align: center;">19</td> <td style="text-align: center;">7</td> <td style="text-align: center;">19</td> </tr> </table> <p>Repeat arcs <i>AC</i> and <i>DF</i> Weight = 38 + 7 = 45</p>	<i>AF</i> = 13	<i>AC</i> = 3	<i>AD</i> = 9	<i>CD</i> = <u>6</u>	<i>DF</i> = <u>4</u>	<i>CF</i> = <u>10</u>	19	7	19	<p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p>	<p>Identifying that these four vertices must be paired.</p> <p>sca these <u>three</u> pairings <u>or</u> explaining why <i>AF, CD</i> and <i>AD, CF</i> should not be used</p> <p><i>AC</i> and <i>DF</i></p> <p>Their 38 (from (ii)) + 7, calculated</p> <p>Could be implied from <u>explicit</u> sight of adding their answers to (i) and (ii), 44+13 (= 57), although this is wrong</p> <p>Allow all three pairings and one correct total</p> <p>May be implied from answer Not dependent on first two marks</p>							
<i>AF</i> = 13	<i>AC</i> = 3	<i>AD</i> = 9																		
<i>CD</i> = <u>6</u>	<i>DF</i> = <u>4</u>	<i>CF</i> = <u>10</u>																		
19	7	19																		



Question		Answer	Marks	Guidance																																									
4	(i)	The number of red bags	B1	Need 'number' <u>and</u> 'red'	Or equivalent, eg 'how many red bags she makes'																																								
4	(ii)	<p><math>x, y</math> and <math>z</math> represent the number of red, yellow and blue bags, respectively</p> <p>The number of sweets used is <math>3x + 7y + 6z</math> and she can use at most 80 sweets</p> <p>Balloons: <math>5x + 4y + 6z \leq 40</math></p> <p>Toys: <math>5x + 2y + 3z \leq 30</math></p>	<p>B1</p> <p>B1</p> <p>B1</p>	<p><math>y</math> must be number of yellow and <math>z</math> number of blue</p> <p>Identifying that this constraint comes from 'sweets'</p> <p><math>5x + 4y + 6z \leq 40</math> or equivalent</p> <p><math>5x + 2y + 3z \leq 30</math> or equivalent</p>	<p>This need not be explicitly stated</p> <p>'Sweets'</p>																																								
4	(iii)	$x \geq 0, y \geq 0, z \geq 0$ <u>and</u> $x, y, z$ are integers	B1	<p>Non-negative <u>and</u> integer-valued</p> <p>Needs to be stated here, not found in answer to part (ii) or (iv)</p>	<p>Or equivalent, <u>both</u> required</p> <p>Condone 'positive integers'</p> <p><math>x \geq 0, y \geq 0, z \geq 0</math> only gets B0</p>																																								
4	(iv)	Lucy sells all the bags she makes	B1	'Sells them all', 'demand matches supply', 'none left over' (or equivalent)																																									
4	(v)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th><math>P</math></th> <th><math>x</math></th> <th><math>y</math></th> <th><math>z</math></th> <th><math>s</math></th> <th><math>t</math></th> <th><math>u</math></th> <th>RHS</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>-1</td> <td>-1</td> <td>-1</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>3</td> <td>7</td> <td>6</td> <td>1</td> <td>0</td> <td>0</td> <td>80</td> </tr> <tr> <td>0</td> <td>5</td> <td>4</td> <td>6</td> <td>0</td> <td>1</td> <td>0</td> <td>40</td> </tr> <tr> <td>0</td> <td>5</td> <td>2</td> <td>3</td> <td>0</td> <td>0</td> <td>1</td> <td>30</td> </tr> </tbody> </table>	$P$	$x$	$y$	$z$	$s$	$t$	$u$	RHS	1	-1	-1	-1	0	0	0	0	0	3	7	6	1	0	0	80	0	5	4	6	0	1	0	40	0	5	2	3	0	0	1	30	<p>B1</p> <p>M1</p> <p>A1</p>	<p>Order of rows or columns may vary</p> <p>columns need not be labelled</p> <p><math>4 \times 8</math> table of numbers with four <b>basis</b> columns (<math>P</math> and slack variables)</p> <p>Constraint rows correct for the <math>x, y, z</math> and RHS columns</p> <p>Objective row has -1 -1 -1 in columns for <math>x, y</math> and <math>z</math></p>	<p>May see additional working for part (vi)</p> <p>Initial tableau must be given in (v)</p> <p>Basis columns must be 0's and a 1</p> <p>Interpret blank entries as 0</p> <p>Follow through their constraints</p> <p>Condone 'sweets' row missing here</p>
$P$	$x$	$y$	$z$	$s$	$t$	$u$	RHS																																						
1	-1	-1	-1	0	0	0	0																																						
0	3	7	6	1	0	0	80																																						
0	5	4	6	0	1	0	40																																						
0	5	2	3	0	0	1	30																																						

Question	Answer	Marks	Guidance																																									
4 (vi)	<p> <math>80 \div 3 = 26.7</math>, <math>40 \div 5 = 8</math> and <math>30 \div 5 = 6</math>  <math>30 \div 5</math> is the least positive ratio                       new R4 = R4 <math>\div</math> 5                      new R1 = R1 + new pivot row                      new R2 = R2 - 3 <math>\times</math> new pivot row                      new R3 = R3 - 5 <math>\times</math> new pivot row                 </p> <table border="1" data-bbox="369 555 954 730"> <thead> <tr> <th><i>P</i></th> <th><i>x</i></th> <th><i>y</i></th> <th><i>z</i></th> <th><i>s</i></th> <th><i>t</i></th> <th><i>u</i></th> <th>RHS</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>-0.6</td> <td>-0.4</td> <td>0</td> <td>0</td> <td>0.2</td> <td>6</td> </tr> <tr> <td>0</td> <td>0</td> <td>5.8</td> <td>4.2</td> <td>1</td> <td>0</td> <td>-0.6</td> <td>62</td> </tr> <tr> <td>0</td> <td>0</td> <td>2</td> <td>3</td> <td>0</td> <td>1</td> <td>-1</td> <td>10</td> </tr> <tr> <td>0</td> <td>1</td> <td>0.4</td> <td>0.6</td> <td>0</td> <td>0</td> <td>0.2</td> <td>6</td> </tr> </tbody> </table>	<i>P</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>s</i>	<i>t</i>	<i>u</i>	RHS	1	0	-0.6	-0.4	0	0	0.2	6	0	0	5.8	4.2	1	0	-0.6	62	0	0	2	3	0	1	-1	10	0	1	0.4	0.6	0	0	0.2	6	<p>B1</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>M1</p> <p>A1</p>	<p>Follow through their tableau if possible, except for final A mark  <math>30 \div 5</math> (as a calculation) <u>or</u> 26.7,8,6 <u>or</u> seeing 'ratio' (or equivalent) and 6   <u>and</u> correct pivot chosen</p> <p>Describing calculation for their pivot row (provided pivot value is positive)</p> <p>Describing calculations for all other rows (must have at least two other rows in their tableau)                      follow through their pivot choice, provided pivot choice is positive</p> <p>A tableau with basis columns for <i>P</i>, <i>x</i> and two of <i>s</i>, <i>t</i>, <i>u</i>, and non-basis columns for <i>y</i>, <i>z</i> and third slack variable, with non-negative values in the column representing RHS of equations</p> <p>(Their) pivot row correct</p> <p>A correct tableau (cao) rows and columns may be interchanged</p>	<p>Some working or answers may be seen in answer to part (v)</p> <p>Allow '<math>\div 5</math>'                      Allow '<math>\div</math> pivot'                      Accept reasonable, consistent, abbreviated forms, must include current row and old or new pivot row (eg R2-3<math>\times</math>pr or R2-3<math>\times</math>R4 or R2-0.6<math>\times</math>R4, but NOT -3<math>\times</math>R4)</p> <p>Correct structure, having pivoted on an element from the <u><i>x</i> column</u>                      Condone omission of objective row and/or <i>P</i> column                      Any other row or column missing <math>\Rightarrow</math> M0, even on follow through</p> <p>Not dependent on previous M1, but pivot value must become 1                      May be achieved on follow through from a smaller initial tableau</p> <p>Dependent on both M marks                      Condone omission of <i>P</i> column only</p>
<i>P</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>s</i>	<i>t</i>	<i>u</i>	RHS																																					
1	0	-0.6	-0.4	0	0	0.2	6																																					
0	0	5.8	4.2	1	0	-0.6	62																																					
0	0	2	3	0	1	-1	10																																					
0	1	0.4	0.6	0	0	0.2	6																																					
4 (vii)	<p> <math>x = 6</math> <math>y = 0</math>, <math>z = 0</math> <span style="float: right;">STRICT FT</span>                       Lucy should make 6 red bags only                 </p>	<p>M1</p> <p>A1</p>	<p>Reading off <u>their</u> values for <u>all three</u> variables, from 1<sup>st</sup> iteration                      6 red (cao), may imply 0 of others</p> <p>Must be explicitly seen, not implied from '6 red'                      Not follow through</p>																																									
4 (viii)	<p>10 yellow bags</p>	<p>B1</p>	<p>Condone <math>x = 0</math>, <math>y = 10</math>, <math>z = 0</math></p> <p>Condone <math>y = 10</math> (with no values given for <math>x</math> and <math>z</math>)</p>																																									

Question	Answer	Marks	Guidance
5 (i)		<p>M1</p> <p>A1</p>	<p>At least five arc weights completed correctly (not <math>BC</math>, which was given)</p> <p>All arc weights completed correctly</p> <p>Ignore arcs to <math>F</math> if shown</p> <p>For remainder of question, follow through from part (i) apart from cao marks or where 'not ft' is stated</p>
5 (ii)	<p><math>BC = 103</math>  <math>BD = 104</math>  <math>CE = 121</math>  <math>BE = 157</math>  <math>CD = 209</math>  <math>AD = 235</math>  <math>AB = 250</math>  <math>DE = 261</math>  <math>AC = 350</math>  <math>AE = 446</math></p>  <p>Total weight = 563 miles</p>	<p>M1</p> <p>A1</p> <p>B1</p> <p>B1</p>	<p>All 10 arc weights listed in correct order (or arcs if weights not shown)</p> <p>Condone weights in correct order without arcs, or with errors in arcs</p> <p>Not selecting <math>BE</math> and <math>CD</math>, having selected <math>BC, BD, CE</math></p> <p>Correct minimum spanning tree drawn</p> <p>563 (cao), units not needed</p> <p>Allow correct list as far as <math>AD = 235</math> even if last four entries are missing or wrong</p> <p>Condone at most one error or omission in first six entries (note: <math>BC = 103</math> is given as first entry)</p> <p>(working must be <u>seen on list</u>)</p> <p>Ignore what happens after <math>CD</math></p> <p>(cao) Ignore any arcs to <math>F</math> if shown</p>
5 (iii)	<p>Two least weight arcs from <math>F</math>  <math>FB = 50</math> and <math>FD = 59</math>                      Lower bound = <math>563 + 50 + 59 = 672</math></p>	<p>M1</p> <p>A1ft</p>	<p>Using <math>FB</math> and <math>FD</math> or <math>50</math> and <math>59</math> or <math>109</math>  <math>672</math> or <math>109 + \text{their } 563</math>, as final answer or stated as lower bound, units not needed</p> <p>Deleting any other vertex <math>\Rightarrow</math> M0                      soi from <math>672</math> or <math>109 + \text{their } 563</math>                      Note: <math>563 + 200 + 250 \Rightarrow</math> M0</p>

Question		Answer	Marks	Guidance	
5	(iv)	$A-F-B-C-E-D-A$	M1	Tour, at least as far as $A-F-B-C-...$	$F$ excluded $\Rightarrow$ M0 Condone shown on a diagram (even without arrows)
		Upper bound $= 200 + 50 + 103 + 121 + 261 + 235 = 970$	A1	970 (cao), units not needed	Answer 970 (without wrong working) $\Rightarrow$ M1, A1
5	(v)	Path $F-A-D$	M1	$F-A-D$ or $D-A-F$ or $FA$ , $AD$ or $DA$ , $AF$	Weights are in (i) and weights from $F$ are: $A=200, B=50, C=150, D=59, E=250$
		Weight = 435	A1	435 (cao), units not needed	Path <u>written down</u> (not implied from 435) Allow $S=D$ , $T=F$ (or vice versa) 435 seen, not implied from $200 + 235$
		Path $B-E-C$	M1	$B-E-C$ or $C-E-B$ or $BE$ , $EC$ or $CE$ , $EB$	Path <u>written down</u> (not implied from 278) Allow $U=B$ , $V=C$ (or vice versa)
		Weight = 278	A1	278 (cao), units not needed	278 seen, not implied from $157+121$
		$FB + DC = 259$ $FC + BD = 254$	M1	$FB + DC = 259$ <u>or</u> $FC + BD = 254$ <u>or</u> 259 and 254 both seen, or equivalent, (not ft) This method mark cannot be implied from the A mark below	<u>Or</u> , $FADBECF = 967$ <u>or</u> $FADCEBF = 972$ , tours with any start vertex and in either direction <u>or</u> 967 and 972 both seen (not ft)
		Join paths using $FC$ and $BD$	A1	$FC$ , $BD$ <u>or</u> 254 (not ft) (Need not be stated as the chosen or least pairing)	$FADBECF$ (oe) <u>or</u> 967 (not ft) Note: 967 with a correct tour $\Rightarrow$ M1, A1 here as well as the final M1, A1
		Tour $FADBECF$	M1	This tour seen, or in reverse, starting at any vertex (not ft)	eg $AFCEBDA$ Not given as a diagram
Total weight = 967	A1	967 (cao), units not needed	Note: 967 with no tour $\Rightarrow$ M0, AO here		

Question		Answer							Marks	Guidance	
6	(i)	A	B	C	D	E	F	Output	M1	A=10, B=128, C=12.8	Initial values and first pass (first row) correct
	10	128	12.8	12	120	8	8	8	A1	D=12, E=120, F=8	
			12	1.2	1	10	2	2	B1	B values are 128, 12, 1, 0	128, 12, 1 and 0 in B column (in this order, and with no others) 8, 2, 1 (in this order, and with no others) in output column
			1	0.1	0	0	1	1	B1	Output 8, 2, 1	
	(ii)	A	B	C	D	E	F	Output	M1	A=10, B=-13, C=-1.3	First pass Dependent on first M1 F=7 from first pass, dependent on both M marks
		10	-13	-1.3	-2	-20	7	7	M1d	D=-2, E=-20	
			-2	-0.2	-1	-10	8	8	A1	F=7	7, 8, 9 (as the first three outputs, in this order)
			-1	-0.1	-1	-10	9	9	B1	Output 7, 8, 9	
			-1	-0.1	-1	-10	9	9			Or an entire row of B to F and output repeated (need not be the correct values, but B ≠ 0)
			...	...	...	...	...	...	B1	Evidence of repeat (cycle, loop)	
		Output 7 8 and then keeps on repeating 9									

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