

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.

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

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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 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 for marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be awarded for an answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must 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 methods must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks in the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) consult 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. Marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the question in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for a particular mark may be specified.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be awarded if an 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. Sometimes this is reinforced in the mark scheme by the abbreviation *isw*. However, this would not apply to a case where a mark is lost 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 otherwise stated; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate a mark dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate fails 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, if 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 work. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) mark is given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a question, various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme. 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 be given for '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 in 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. 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 accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, consult your Team Leader.

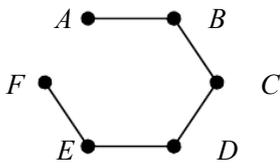
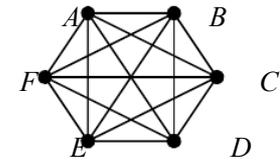
- g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examine 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 (complete) attempt and ignore the others.

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

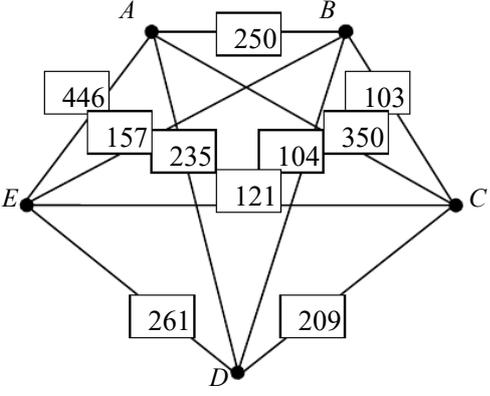
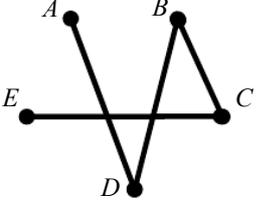
- h For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain the same according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally withheld. This may differ for some units. This 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.

Question	Answer	Marks	Guidance
2 (i)	eg 	B1	Any tree drawn on the six vertices Must be a tree simply connected May need to be consistent with
2 (ii)	5 	B1	Complete graph drawn on the six vertices Must have 6 vertices Arcs may be straight lines Check diagram
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) 12 (cao) seen Even if from 2
2 (iv)	<u>Exactly</u> two odd order vertices (or equivalent) eg <i>FACEBAD</i>	B1	<i>F</i> and <i>D</i> are the <u>only</u> odd nodes <i>F</i> and <i>D</i> have order 1 <u>and</u> all the other nodes have even orders List all orders <u>and</u> identify <i>F</i> and <i>D</i> Condone ‘ <u>two</u> odd nodes, <i>F</i> and <i>D</i> ’ NOT ‘one pair’ NOT ‘two odd’ without further NOT ‘ <i>F</i> and <i>D</i> ’ Any one of the answers

Question	Answer	Marks	Guidance																									
3 (i)	<div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;"> <p><i>A</i></p> <table border="1" style="border-collapse: collapse;"> <tr><td>1</td><td>0</td></tr> <tr><td> </td><td> </td></tr> </table> </div> <div style="text-align: center;"> <p><i>B</i></p> <table border="1" style="border-collapse: collapse;"> <tr><td>3</td><td>5</td></tr> <tr><td>6</td><td>5</td></tr> </table> </div> <div style="text-align: center;"> <p><i>D</i></p> <table border="1" style="border-collapse: collapse;"> <tr><td>5</td><td>9</td></tr> <tr><td>9</td><td> </td></tr> </table> </div> <div style="text-align: center;"> <p><i>F</i></p> <table border="1" style="border-collapse: collapse;"> <tr><td>6</td><td>13</td></tr> <tr><td>14</td><td>13</td></tr> </table> </div> </div> <div style="display: flex; justify-content: center; margin-top: 10px;"> <div style="text-align: center; margin-right: 20px;"> <p><i>C</i></p> <table border="1" style="border-collapse: collapse;"> <tr><td>2</td><td>3</td></tr> <tr><td>3</td><td> </td></tr> </table> </div> <div style="text-align: center;"> <p><i>E</i></p> <table border="1" style="border-collapse: collapse;"> <tr><td>4</td><td>8</td></tr> <tr><td>8</td><td> </td></tr> </table> </div> </div> <p style="margin-top: 20px;">Route <i>A-C-B-D-F</i></p> <p>Weight 13</p>	1	0			3	5	6	5	5	9	9		6	13	14	13	2	3	3		4	8	8		<p>M1 Correct updating at <i>B</i> (6 and 5 in lower box, and nothing else)</p> <p>A1 All temporary labels correct, not implied from permanent labels. No extra values. No updating at <i>D, E</i></p> <p>M1 All permanent labels correct. Not dependent on previous method mark</p> <p>A1 All order of labelling values correct Dependent on M mark for permanent labels</p> <p>B1 <i>ACBDF</i> (cao) or in reverse</p> <p>B1 13 (cao)</p>	<p>May be considered correct if order of labelling is correct</p> <p>Condone blank boxes</p> <p>Condone all routes</p> <p>Not fit</p> <p>Written down</p> <p>Written down</p>	
1	0																											
3	5																											
6	5																											
5	9																											
9																												
6	13																											
14	13																											
2	3																											
3																												
4	8																											
8																												
3 (ii)	<p>Total weight of all arcs in network = 38</p> <p>Only odd nodes are <i>C</i> and <i>D</i></p> <p>Repeat shortest path from <i>C</i> to <i>D</i></p> <p>weight = 6</p> <p>Weight = 38 + 6 = 44</p>	<p>B1 38 seen</p> <p>B1 <u>Both</u> <i>CD</i> (or <i>C-B-D</i>) <u>and</u> 6 seen</p> <p>B1 44</p>		<p>Or 6 + their 38</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> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="text-align: center;"> $AF = 13$ $CD = \frac{6}{19}$ </div> <div style="text-align: center;"> $AC = 3$ $DF = \frac{4}{7}$ </div> <div style="text-align: center;"> $AD = 9$ $CF = \frac{10}{19}$ </div> </div> <p>Repeat arcs <i>AC</i> and <i>DF</i></p> <p>Weight = 38 + 7 = 45</p>	<p>M1 Identifying that these four vertices must be paired.</p> <p>A1 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>M1 <i>AC</i> and <i>DF</i></p> <p>A1 Their 38 (from (ii)) + 7, calculated</p>		<p>Could be implied by adding their arcs (44+13 (= 57),</p> <p>Allow all three pairings</p> <p>correct total</p> <p>May be implied</p> <p>Not dependent</p>																								

Question		Answer	Marks	Guidance																																								
4	(i)	The number of red bags	B1	Need 'number' and 'red'																																								
4	(ii)	<p>x, y and z represent the number of red, yellow and blue bags, respectively</p> <p>The number of sweets used is $3x + 7y + 6z$ and she can use at most 80 sweets</p> <p>Balloons: $5x + 4y + 6z \leq 40$</p> <p>Toys: $5x + 2y + 3z \leq 30$</p>	<p>B1</p> <p>B1</p> <p>B1</p>	<p>y must be number of yellow and z number of blue</p> <p>Identifying that this constraint comes from 'sweets'</p> <p>$5x + 4y + 6z \leq 40$ or equivalent</p> <p>$5x + 2y + 3z \leq 30$ or equivalent</p>																																								
4	(iii)	$x \geq 0, y \geq 0, z \geq 0$ and x, y, z are integers	B1	<p>Non-negative and integer-valued</p> <p>Needs to be stated here, not found in answer to part (ii) or (iv)</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>P</th> <th>x</th> <th>y</th> <th>z</th> <th>s</th> <th>t</th> <th>u</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>4×8 table of numbers with four basis columns (P and slack variables)</p> <p>Constraint rows correct for the x, y, z and RHS columns</p> <p>Objective row has -1 -1 -1 in columns for x, y and z</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)	$80 \div 3 = 26.7$, $40 \div 5 = 8$ and $30 \div 5 = 6$ $30 \div 5$ is the least positive ratio new R4 = R4 \div 5 new R1 = R1 + new pivot row new R2 = R2 - 3 \times new pivot row new R3 = R3 - 5 \times new pivot row <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>P</th> <th>x</th> <th>y</th> <th>z</th> <th>s</th> <th>t</th> <th>u</th> <th>RHS</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>-0.6</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>	P	x	y	z	s	t	u	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	B1 Follow through their tableau if possible, except for final A mark $30 \div 5$ (as a calculation) or 26.7,8,6 or seeing 'ratio' (or equivalent) and 6 and correct pivot chosen B1 Describing calculation for their pivot row (provided pivot value is positive) B1 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 M1 A tableau with basis columns for P , x and two of s , t , u , and non-basis columns for y , z and third slack variable, with non-negative values in the column representing RHS of equations M1 (Their) pivot row correct A1 A correct tableau (cao) rows and columns may be interchanged	Sc... ing in an... Allow ' \div 5' Allow ' \div pivo... Accept reason... abbreviated fo... current row an... (eg R2-3 \times pr... R2-0.6 \times R4, b... Correct struct... element from... Condone omis... and/or P colu... Any other row... \Rightarrow M0, even o... Not dependent... pivot value m... May be achiev... from a smaller... Dependent on... Condone omis...
P	x	y	z	s	t	u	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)	$x = 6$, $y = 0$, $z = 0$ STRICT FT Lucy should make 6 red bags only	M1 Reading off their values for all three variables, from 1 st iteration A1 6 red (cao), may imply 0 of others	Must be explic... from '6 red' Not follow thr...																																								
4 (viii)	10 yellow bags	B1	Condone $x = 0$, $y = 10$, $z = 0$ Condone $y = 10$ (for x and z)																																								

Question	Answer	Marks	Guidance
5 (i)		<p>M1</p> <p>A1</p>	<p>At least five arc weights completed correctly (not BC, which was given)</p> <p>All arc weights completed correctly</p> <p>Ignore a</p> <p>For remainder through from marks or when</p>
5 (ii)	<p> $BC = 103$ $BD = 104$ $CE = 121$ $BE = 157$ $CD = 209$ $AD = 235$ $AB = 250$ $DE = 261$ $AC = 350$ $AE = 446$ </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 BE and CD, having selected BC, BD, CE</p> <p>Correct minimum spanning tree drawn</p> <p>563 (cao), units not needed</p> <p>Allow correct even if last few wrong</p> <p>Condone at m in first six ent given as first e</p> <p>(working must Ignore what h</p> <p>(cao) Ignore an</p>
5 (iii)	<p>Two least weight arcs from F $FB = 50$ and $FD = 59$ Lower bound = $563 + 50 + 59 = 672$</p>	<p>M1</p> <p>A1ft</p>	<p>Using FB and FD or 50 and 59 or 109 672 or $109 + 563$, as final answer or stated as lower bound, units not needed</p> <p>Deleting any soi from 672 Note: $563 + 20$</p>

Question		Answer	Marks	Guidance
5	(iv)	$A-F-B-C-E-D-A$	M1	Tour, at least as far as $A-F-B-C-...$
		Upper bound $= 200 + 50 + 103 + 121 + 261 + 235 = 970$	A1	970 (cao), units not needed
5	(v)	Path $F-A-D$	M1	In this part each A mark depends only on the M1 immediately preceding it $F-A-D$ or $D-A-F$ or FA, AD or DA, AF
		Weight = 435	A1	435 (cao), units not needed
		Path $B-E-C$	M1	$B-E-C$ or $C-E-B$ or BE, EC or CE, EB
		Weight = 278	A1	278 (cao), units not needed
		$FB + DC = 259$ $FC + BD = 254$	M1	$FB + DC = 259$ or $FC + BD = 254$ or 259 and 254 both seen, or equivalent, (not ft) This method mark cannot be implied from the A mark below
		Join paths using FC and BD	A1	FC, BD or 254 (not ft) (Need not be stated as the chosen or least pairing)
		Tour $FADBECF$	M1	This tour seen, or in reverse, starting at any vertex (not ft)
Total weight = 967	A1	967 (cao), units not needed		

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