

Mathematics

Advanced GCE

Unit **4737**: Decision Mathematics 2

Mark Scheme for January 2013

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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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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
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

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.

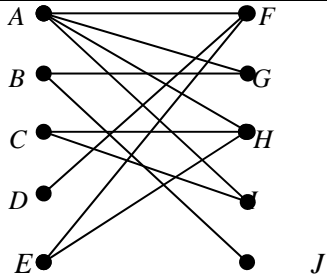
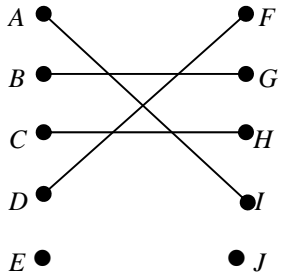
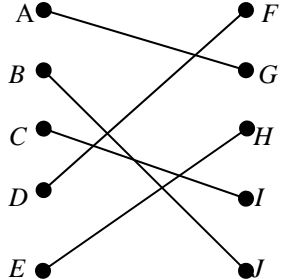
- f. Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (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. NB Follow these maths-specific instructions rather than those in the assessor handbook.

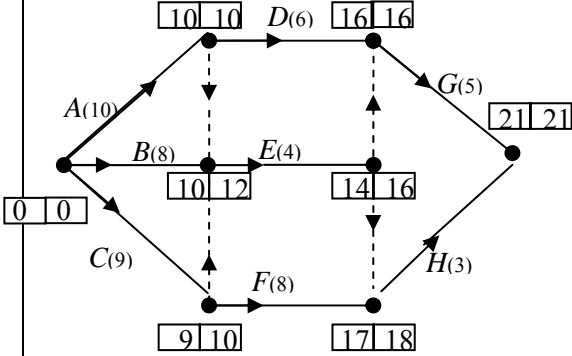
If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

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.

- 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.

Question		Answer	Marks	Guidance
1	(i)		B1 [1]	Bipartite graph correct (ignore any extra thickening of lines, labels attached for alternating paths, or an additional arc to X for alternating path)
1	(ii)	$D = F - A = I$ 	B1 B1 [2]	A valid alternating path from D, written down in some form, not just read off from labels on graph. This matching drawn (cao)
1	(iii)	$E = H - C = I - A = G - B = J$ 	B1 B1 [2]	This alternating path, written down in some form, not just read off from labels on graph. Allow reversed. This matching drawn (cao)
1	(iv)	<p><i>J can only pair with B and D must pair with F</i> <i>Hence G must pair with A, H must pair with E and C with I</i></p>	M1 A1 [2]	<i>J must pair with B, D must pair with F</i> <i>Explaining why A = G, C = I and E = H</i>

2	Question	Answer	Marks	Guidance																											
2	(i)	<table border="1" data-bbox="423 240 954 592"> <thead> <tr> <th>Activity</th> <th>Duration</th> <th>Immediate predecessors</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>10</td> <td>-</td> </tr> <tr> <td>B</td> <td>8</td> <td>-</td> </tr> <tr> <td>C</td> <td>9</td> <td>-</td> </tr> <tr> <td>D</td> <td>6</td> <td>A</td> </tr> <tr> <td>E</td> <td>4</td> <td>A, B, C</td> </tr> <tr> <td>F</td> <td>8</td> <td>C</td> </tr> <tr> <td>G</td> <td>5</td> <td>D, E</td> </tr> <tr> <td>H</td> <td>3</td> <td>E, F</td> </tr> </tbody> </table>	Activity	Duration	Immediate predecessors	A	10	-	B	8	-	C	9	-	D	6	A	E	4	A, B, C	F	8	C	G	5	D, E	H	3	E, F	<p>B1</p> <p>B1</p> <p>[2]</p>	<p>Immediate predecessors correct for A to F (blank implies 'none')</p> <p>Immediate predecessors correct for G and H</p>
Activity	Duration	Immediate predecessors																													
A	10	-																													
B	8	-																													
C	9	-																													
D	6	A																													
E	4	A, B, C																													
F	8	C																													
G	5	D, E																													
H	3	E, F																													
2	(ii)	 <p data-bbox="423 1043 831 1075">Min completion time = 21 minutes</p> <p data-bbox="423 1114 730 1145">Critical activities: A, D, G</p>	<p>M1</p> <p>M1</p> <p>A1</p> <p>B1</p> <p>B1</p> <p>[5]</p>	<p>Forward pass with at most one independent error</p> <p>Backward pass with at most one independent error</p> <p>Both passes correct (cao)</p> <p>21 mins (cao) <u>with units</u></p> <p>A, D, G (cao)</p>																											

Question		Answer	Marks	Guidance
2	(iii)	<i>B</i> and <i>E</i>	M1 A1 [2]	Either correct and no critical activities listed Both correct and no incorrect activities (cao)
2	(iv)	It would increase by 2 mins <i>D</i> or <i>G</i>	B1 B1 [2]	Minimum completion time increases by 2, or time = 23 [(their) 21 + 2] Either (or both) of the critical activities (cao)
2	(v)	1 minute delay	B1 [1]	1 or time is now 22 [(their) 21 + 1]

Question		Answer	Marks	Guidance																																																
3	(i)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th></th> <th><i>N</i></th> <th><i>P</i></th> <th><i>R</i></th> <th><i>T</i></th> </tr> </thead> <tbody> <tr> <th><i>J</i></th> <td>3</td> <td>2</td> <td>2</td> <td>2</td> </tr> <tr> <th><i>K</i></th> <td>2</td> <td>6</td> <td>5</td> <td>3</td> </tr> <tr> <th><i>L</i></th> <td>5</td> <td>9</td> <td>10</td> <td>6</td> </tr> <tr> <th><i>M</i></th> <td>2</td> <td>7</td> <td>6</td> <td>6</td> </tr> </tbody> </table> <p>She needs to convert a maximising problem into a minimising problem</p>		<i>N</i>	<i>P</i>	<i>R</i>	<i>T</i>	<i>J</i>	3	2	2	2	<i>K</i>	2	6	5	3	<i>L</i>	5	9	10	6	<i>M</i>	2	7	6	6	B1 B1 [2]	This matrix, with or without row and column headings (cao) Hungarian algorithm finds allocation with minimum total Maximising correct guesses is same as minimising incorrect guesses																							
	<i>N</i>	<i>P</i>	<i>R</i>	<i>T</i>																																																
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<i>K</i>	2	6	5	3																																																
<i>L</i>	5	9	10	6																																																
<i>M</i>	2	7	6	6																																																
3	(ii)	<p>Reduce rows</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tbody> <tr><td>1</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>4</td><td>3</td><td>1</td></tr> <tr><td>0</td><td>4</td><td>5</td><td>1</td></tr> <tr><td>0</td><td>5</td><td>4</td><td>4</td></tr> </tbody> </table> <p>Columns are already reduced</p> <p>Cross through zeros</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tbody> <tr><td>1</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>4</td><td>3</td><td>1</td></tr> <tr><td>0</td><td>4</td><td>5</td><td>1</td></tr> <tr><td>0</td><td>5</td><td>4</td><td>4</td></tr> </tbody> </table> <p>Augment by 1</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tbody> <tr><td>2</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>3</td><td>2</td><td>0</td></tr> <tr><td>0</td><td>3</td><td>4</td><td>0</td></tr> <tr><td>0</td><td>4</td><td>3</td><td>3</td></tr> </tbody> </table>	1	0	0	0	0	4	3	1	0	4	5	1	0	5	4	4	1	0	0	0	0	4	3	1	0	4	5	1	0	5	4	4	2	0	0	0	0	3	2	0	0	3	4	0	0	4	3	3	M1 A1 M1 A1	Reducing rows or columns (for their matrix or for the original) Reducing rows and columns correctly (no arithmetic errors) Condone columns reduced first followed by rows If original (speculations matrix) is used no augmenting is possible so no further M or A marks. Crossing through zeros using min no of lines and augmenting by min uncovered value (method correct, including entries crossed out twice). Correct augmented matrix (cao)
1	0	0	0																																																	
0	4	3	1																																																	
0	4	5	1																																																	
0	5	4	4																																																	
1	0	0	0																																																	
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0	3	4	0																																																	
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Question	Answer	Marks	Guidance																																
3 (ii)	<p>Augment by 2</p> <table border="1" data-bbox="474 240 792 384"> <tr><td>4</td><td>0</td><td>0</td><td>2</td></tr> <tr><td>0</td><td>1</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>2</td><td>0</td></tr> <tr><td>0</td><td>2</td><td>1</td><td>3</td></tr> </table> <p>Jill = police officer Kevin = radiographer Liz = teacher Mike = nurse</p>	4	0	0	2	0	1	0	0	0	1	2	0	0	2	1	3	<p>M1 A1 B1 B1</p> <p>[8]</p>	<p>Crossing through zeros using min no of lines and augmenting a second time by min uncovered value (method correct, including entries crossed out twice)</p> <p>Correct augmented matrix (cao)</p> <p>Correctly describing how each table has been formed (eg stating ‘reduce rows’, ‘augment by 1’, etc.)</p> <p>Correct allocation (cao) in words or symbols</p>																
4	0	0	2																																
0	1	0	0																																
0	1	2	0																																
0	2	1	3																																
3 (iii)	<p>Remove row for <i>L</i> and column for <i>R</i></p> <table border="1" data-bbox="430 683 958 826"> <tr><td></td><td><i>N</i></td><td><i>P</i></td><td><i>T</i></td></tr> <tr><td><i>J</i></td><td>7</td><td>8</td><td>8</td></tr> <tr><td><i>K</i></td><td>8</td><td>4</td><td>7</td></tr> <tr><td><i>M</i></td><td>8</td><td>3</td><td>4</td></tr> </table> <p>$J = P$ $K = T$ $M = N$</p> <p>This solution involves $8+7+8 = 23$ correct guesses. The maximum possible is 24, but that is not feasible since Kevin and Mike would both need to be the nurse (or Jill would have to be both the police officer and the teacher)</p>		<i>N</i>	<i>P</i>	<i>T</i>	<i>J</i>	7	8	8	<i>K</i>	8	4	7	<i>M</i>	8	3	4	<p>B1 B1</p> <p>[2]</p>	<p>Or on reduced cost matrix</p> <table border="1" data-bbox="1294 683 1720 826"> <tr><td></td><td><i>N</i></td><td><i>P</i></td><td><i>T</i></td></tr> <tr><td><i>J</i></td><td>3</td><td>2</td><td>2</td></tr> <tr><td><i>K</i></td><td>2</td><td>6</td><td>3</td></tr> <tr><td><i>M</i></td><td>2</td><td>7</td><td>6</td></tr> </table> <p>Same allocation as before except that now Kevin is the teacher (need not see working)</p> <p>A valid explanation, using numbers of guesses or reduced costs (or showing correct use of Hungarian from reduced start matrix, but not just using reduced cost matrix from (ii) with third row and third column removed)</p>		<i>N</i>	<i>P</i>	<i>T</i>	<i>J</i>	3	2	2	<i>K</i>	2	6	3	<i>M</i>	2	7	6
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<i>M</i>	2	7	6																																

Question		Answer	Marks	Guidance
4	(i)	A supersource, S , and arc $S S_1$ with lower capacity 13, and upper capacity ≥ 22 .	B1	Or supersource, S , and arc $S S_1$ with $0 \leq$ lower capacity ≤ 13 and upper capacity ≥ 22
		A supersource, S , and arc $S S_2$ with lower capacity 0 and upper capacity ≥ 9	B1 [2]	
4	(ii)	Maximum = $8+10+10-2+15$ = 41 litres per second	M1 A1	Evidence of using -2 for arc BC 41, units not required
		Minimum = $3+1+8-3+2 = 11$ litres per second	B1 [3]	11, units not required
4	(iii)	Arcs crossed in forwards direction: $AD = 10, S_1B = 10, S_2C = 9, ED = 5, ET = 20$ Arcs crossed in backwards direction: $CE = -2, BE = -5$ (AE is crossed twice so any flow is cancelled out) $10+10+9-2-5+5+20 = 47$ (answer given)	M1 A1 [2]	Seeing evidence of -2 and -5 Not including AE (or cancelling it with itself, rather than +8 and -1)

Question	Answer	Marks	Guidance
4 (iv)		<p>M1</p> <p>A1</p> <p>[2]</p>	<p>May also show arcs from S, ignore the flows on these if shown (should be 13 and 0) (must be flows, not labelling procedure) Arcs S_1A, S_1B, S_2C, AE, CE and DT correct</p> <p>All correct, including direction on DE</p>
4 (v)	<p>$S_1ADT = 6$ $S_2CET = 7$ Total = 13</p>	<p>B1</p> <p>[1]</p>	<p>13, or 6 and 7 or 6+7 (cao)</p>
4 (vi)	<p>Maximum flow = 30 For example, the flow in (iv) plus the extra 13 plus $S_1BEDT = 2$ and $S_2CEDT = 2$</p> <p>Cut $\{S_1, S_2, A, B, C, D, E\}, \{T\}$ is saturated</p>	<p>B1</p> <p>B1</p> <p>[2]</p>	<p>Could 'start from scratch' or give a description of how to 'tweak' the flow</p> <p>30 and a valid flow shown on diagram (assume blanks mean 0, direction not required on DE if no flow in it) Or 30 and a convincing description of flow (do not need to say explicitly that this shows that 30 is feasible)</p> <p>This cut described in any way and some words like 'arcs are full' or '=30' (accept 'max flow = min cut' without further explanation, here)</p>

Question		Answer	Marks	Guidance																														
5	(i)	4 when he chooses \diamond	B1 [1]	4 and \diamond																														
5	(ii)	<p>\blacklozenge is dominated by \blacksquare</p> <p>Rose always wins more by choosing \blacksquare $(4 > 2, -3 > -5, 4 > -2 \text{ and } 5 > -1)$ Colin should never choose \triangle</p> <table style="margin-left: 20px;"> <tr> <td></td> <td>\circ</td> <td>\square</td> <td>\diamond</td> </tr> <tr> <td>\bullet</td> <td>-2</td> <td>3</td> <td>-4</td> </tr> <tr> <td>\blacksquare</td> <td>4</td> <td>-3</td> <td>4</td> </tr> <tr> <td>\blacktriangle</td> <td>-6</td> <td>5</td> <td>-5</td> </tr> </table>		\circ	\square	\diamond	\bullet	-2	3	-4	\blacksquare	4	-3	4	\blacktriangle	-6	5	-5	B1 M1 A1 [3]	<p>\blacksquare dominates or \blacksquare is <u>always</u> better or correct comparisons seen</p> <p>\triangle</p> <p>This reduced matrix (cao)</p>														
	\circ	\square	\diamond																															
\bullet	-2	3	-4																															
\blacksquare	4	-3	4																															
\blacktriangle	-6	5	-5																															
5	(iii)	<table style="margin-left: 20px;"> <tr> <td></td> <td>\circ</td> <td>\square</td> <td>\diamond</td> <td>row min</td> </tr> <tr> <td>\bullet</td> <td>-2</td> <td>3</td> <td>-4</td> <td>-4</td> </tr> <tr> <td>\blacksquare</td> <td>4</td> <td>-3</td> <td>4</td> <td>-3</td> </tr> <tr> <td>\blacktriangle</td> <td>-6</td> <td>5</td> <td>-5</td> <td>-6</td> </tr> <tr> <td>col</td> <td>4</td> <td>5</td> <td>4</td> <td></td> </tr> <tr> <td>max</td> <td>\uparrow</td> <td></td> <td>\uparrow</td> <td></td> </tr> </table> <p>Play-safe for Rose is \blacksquare</p> <p>Play-safes for Colin are \circ and \diamond</p> <p>Not stable, $4 \neq -3$</p>		\circ	\square	\diamond	row min	\bullet	-2	3	-4	-4	\blacksquare	4	-3	4	-3	\blacktriangle	-6	5	-5	-6	col	4	5	4		max	\uparrow		\uparrow		M1 M1 A1 B1 [4]	<p>Row min values shown</p> <p>Column maxima (or their negatives) shown</p> <p>\blacksquare, \circ and \diamond written down (ft their table), dependent on both M marks</p> <p>Not stable and a valid reason (eg if R plays \blacksquare then C should choose \square) (ft their table, including stable/not stable)</p>
	\circ	\square	\diamond	row min																														
\bullet	-2	3	-4	-4																														
\blacksquare	4	-3	4	-3																														
\blacktriangle	-6	5	-5	-6																														
col	4	5	4																															
max	\uparrow		\uparrow																															

Question	Answer	Marks	Guidance									
5 (iv)	<p>On the reduced matrix, add 6 throughout to remove negative values</p> <table border="1" data-bbox="555 308 808 416"> <tr> <td>4</td> <td>9</td> <td>2</td> </tr> <tr> <td>10</td> <td>3</td> <td>10</td> </tr> <tr> <td>0</td> <td>11</td> <td>1</td> </tr> </table> <p>If Colin chooses <input type="checkbox"/> then Rose can expect to win $9x + 3y + 11z$ points</p>	4	9	2	10	3	10	0	11	1	<p>M1</p> <p>A1</p> <p>[2]</p>	<p>Add 6 to values in table (either described or table shown, or at least <input type="checkbox"/> column shown)</p> <p><input type="checkbox"/> column identified</p>
4	9	2										
10	3	10										
0	11	1										
5 (v)	<p>Using $x = \frac{7}{48}$, $y = \frac{27}{48}$, $z = \frac{14}{48}$</p> <p>$4x + 10y = \frac{298}{48}$ or $6\frac{5}{24}$ or 6.21</p> <p>$9x + 3y + 11z = \frac{298}{48}$ or $6\frac{5}{24}$ or 6.21</p> <p>$2x + 10y + z = \frac{298}{48}$ or $6\frac{5}{24}$ or 6.21</p> <p>$m = 6\frac{5}{24} \Rightarrow M = \frac{5}{24}$</p>	<p>M1</p> <p>A1</p> <p>[2]</p>	<p>$\frac{298}{48}$ or $6\frac{5}{24}$ or 6.21 (to 3 sf) (cao), even if seen with no working shown or from only one expression (may be implied from M correct)</p> <p>$\frac{5}{24}$ or 0.208 (to 3 sf) or 0.21 (to 2 sf) (cao)</p>									

Question		Answer	Marks	Guidance																																																						
6	(i)	<p>(4; 0) would mean that at the start of Friday morning Simon has no houses in store.</p> <p>He needs four houses for Friday, but he can only make at most three, so he needs at least one in store.</p>	<p>M1</p> <p>A1</p> <p>[2]</p>	<p>Understanding that (4; 0) means no houses stored from Thursday to Friday</p> <p>Explaining why he would need <u>at least</u> one stored, or equivalent</p>																																																						
6	(ii)		<p>B1</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>B1</p> <p>[6]</p>	<p>Arcs correct for Tuesday</p> <p>Arcs correct for Wednesday</p> <p>Arcs correct for Thursday</p> <p>Weights (costs) correct for Friday</p> <p>Weights correct for Tuesday to Thursday (ft arcs, provided 1, 4 or 9)</p> <p>Weights correct for Monday</p>																																																						
6	(iii)	<table border="1"> <thead> <tr> <th>Stage</th> <th>State</th> <th>Action</th> <th>Working</th> <th>Suboptimal minimum</th> </tr> </thead> <tbody> <tr> <td rowspan="2">4</td> <td>1</td> <td>0</td> <td>9</td> <td>9</td> </tr> <tr> <td>2</td> <td>0</td> <td>4</td> <td>4</td> </tr> <tr> <td rowspan="3">3</td> <td>0</td> <td>1</td> <td>9 + 9 = 18</td> <td>18</td> </tr> <tr> <td rowspan="2">1</td> <td>1</td> <td>4 + 9 = 13</td> <td rowspan="2">13</td> </tr> <tr> <td>2</td> <td>9 + 4 = 13</td> </tr> <tr> <td rowspan="3">2</td> <td>0</td> <td>0</td> <td>4 + 18 = 22</td> <td>22</td> </tr> <tr> <td rowspan="2">1</td> <td>0</td> <td>1 + 18 = 19</td> <td rowspan="2">17</td> </tr> <tr> <td>1</td> <td>4 + 13 = 17</td> </tr> <tr> <td rowspan="3">1</td> <td>0</td> <td>0</td> <td>9 + 22 = 31</td> <td rowspan="2">26</td> </tr> <tr> <td rowspan="2">1</td> <td>0</td> <td>4 + 22 = 26</td> </tr> <tr> <td></td> <td>1</td> <td>9 + 17 = 26</td> </tr> <tr> <td rowspan="2">0</td> <td rowspan="2">0</td> <td>0</td> <td>8 + 31 = 39</td> <td rowspan="2">39</td> </tr> <tr> <td>1</td> <td>27 + 26 = 53</td> </tr> </tbody> </table>	Stage	State	Action	Working	Suboptimal minimum	4	1	0	9	9	2	0	4	4	3	0	1	9 + 9 = 18	18	1	1	4 + 9 = 13	13	2	9 + 4 = 13	2	0	0	4 + 18 = 22	22	1	0	1 + 18 = 19	17	1	4 + 13 = 17	1	0	0	9 + 22 = 31	26	1	0	4 + 22 = 26		1	9 + 17 = 26	0	0	0	8 + 31 = 39	39	1	27 + 26 = 53	<p>B1</p> <p>M1</p> <p>A1</p> <p>B1</p> <p>M1</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>[8]</p>	<p>Follow through their part (ii) if possible for M and B marks</p> <p>Columns for stage, state, action and at least one other column for numerical work</p> <p>Stage and state values correct, starting from stage 4</p> <p>Action values correct (= state value for next stage)</p> <p>Suboptimal min values correct for stage 4</p> <p>Correct method for stage 3</p> <p>Correct method for stage 2</p> <p>Correct method for stage 1</p> <p>Completely correct values for suboptimal minima throughout (dependent on all three method marks)</p>
Stage	State	Action	Working	Suboptimal minimum																																																						
4	1	0	9	9																																																						
	2	0	4	4																																																						
3	0	1	9 + 9 = 18	18																																																						
	1	1	4 + 9 = 13	13																																																						
		2	9 + 4 = 13																																																							
2	0	0	4 + 18 = 22	22																																																						
	1	0	1 + 18 = 19	17																																																						
		1	4 + 13 = 17																																																							
1	0	0	9 + 22 = 31	26																																																						
	1	0	4 + 22 = 26																																																							
			1	9 + 17 = 26																																																						
0	0	0	8 + 31 = 39	39																																																						
		1	27 + 26 = 53																																																							
6	(iv)	<p>Mon Tue Wed Thurs Friday</p> <p>2 3 2 3 3</p>	<p>B1</p> <p>[1]</p>	<p>Cao</p>																																																						

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