

Mathematics (MEI)

Advanced GCE

Unit **4773**: Decision Mathematics Computation

Mark Scheme for June 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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Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

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 in mark scheme	Meaning
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
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

- 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.

E

A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

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

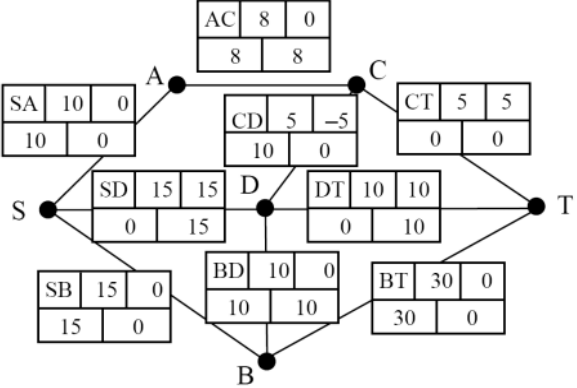
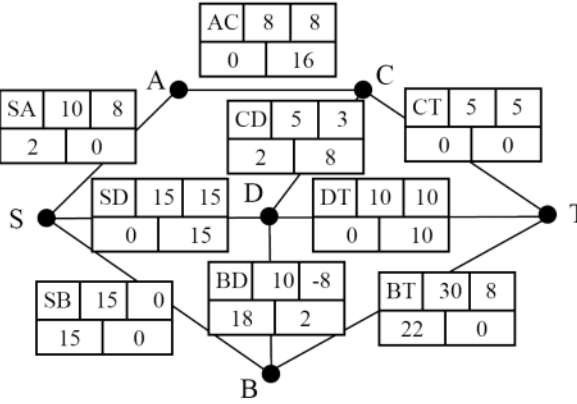
If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

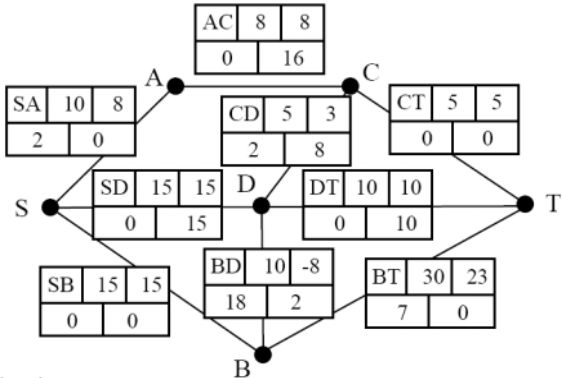
If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

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.

1	Question	Answer	Marks	Guidance						
1	(i)	<p>Key: (the forward direction is defined by the order of the letters on the arc name)</p> <table border="1" data-bbox="472 296 745 411"> <tr> <td>Arc</td> <td>Capacity</td> <td>Flow</td> </tr> <tr> <td>forward potential</td> <td colspan="2">backward potential</td> </tr> </table> 	Arc	Capacity	Flow	forward potential	backward potential		<p>B1 B1 FT B1 FT</p> <p>[3]</p>	<p>capacities and flows forward potentials backward potentials</p>
Arc	Capacity	Flow								
forward potential	backward potential									
1	(ii)	<p>e.g. flow-augmenting path ... SACDBT (8)</p> 	<p>B1 B1</p> <p>M1 A1</p> <p>[4]</p>							

Question		Answer	Marks	Guidance
1	(iii)	<p>e.g. flow-augmenting path ... SBT (15)</p>  <pre> graph LR S((S)) -- SA --> A((A)) S -- SD --> D((D)) S -- SB --> B((B)) A -- AC --> C((C)) C -- CD --> D C -- CT --> T((T)) D -- DT --> T D -- BD --> B B -- BT --> T </pre> <p>The diagram shows a network flow graph with nodes S, A, B, C, D, and T. Each edge is represented by a box containing flow, capacity, and residual values. The edges and their values are:</p> <ul style="list-style-type: none"> SA: flow 10, capacity 8, residual 2 0 AC: flow 8, capacity 8, residual 0 16 CD: flow 5, capacity 3, residual 2 8 CT: flow 5, capacity 5, residual 0 0 SD: flow 15, capacity 15, residual 0 15 DT: flow 10, capacity 10, residual 0 10 SB: flow 15, capacity 15, residual 0 0 BD: flow 10, capacity -8, residual 18 2 BT: flow 30, capacity 23, residual 7 0 	<p>B1</p> <p>B1</p> <p>[2]</p>	
1	(iv)	<p>Flow is now 38 But cut SA/BCDT has capacity 38 So flow is maximal</p>	<p>M1</p> <p>A1</p> <p>[2]</p>	<p>max flow/min cut cao</p>

Question		Answer	Marks	Guidance
1	(v)	e.g. max SA + SD + SB st SA + CA – AC = 0 AC + DC – CA – CD – CT = 0 SD + CD + BD – DC – DB – DT = 0 SB + DB – BD – BT = 0 SA < 10 SD < 15 SB < 15 AC < 8 CA < 8 CD < 5 DC < 5 BD < 10 DB < 10 CT < 5 DT < 10 BT < 30 end LP OPTIMUM FOUND AT STEP 2 OBJECTIVE FUNCTION VALUE 1) 38.00000 VARIABLE VALUE SA 8.000000 SD 15.000000 SB 15.000000 CA 0.000000 AC 8.000000 DC 0.000000 CD 5.000000 CT 3.000000 BD 0.000000 DB 10.000000 DT 10.000000 BT 25.000000 Different solution ... CT down 2 CD, DB, BT up 2 ... with same flow	B1 M1 A1 M1 A1 B1	objective 4 balancing equations capacities + back capacities running interpretation
			[7]	

Question	Answer	Marks	Guidance
2	<p>e.g.</p> <pre> min 30000xa1 + 33000xa2 + 35000xa3 + 28000xb1 + 31000xb2 + 33000xb3 + 27000xc2 + 29000xc3 + 28000xd2 + 30000xd3 + 800000c + 1400000d st xa - xa1 - xa2 - xa3 = 0 xb - xb1 - xb2 - xb3 = 0 xc - xc2 - xc3 = 0 xd - xd2 - xd3 = 0 xa1 + xb1 > 600 xa2 + xb2 + xc2 + xd2 > 850 xa3 + xb3 + xc3 + xd3 > 750 xc2 - 1000c2 < 0 xc3 - 1000c3 < 0 c2 - c3 < 0 xd2 - 1000d2 < 0 xd3 - 1000d3 < 0 d2 - d3 < 0 c2 + c3 - 10c < 0 d2 + d3 - 10d < 0 2xa2 + 0.1xb2 - xc2 - 1.9xd2 > 0 2xa3 + 0.1xb3 - xc3 - 1.9xd3 > 0 xa < 650 xb < 950 xc < 625 xd < 840 end int c2 int c3 int d2 int d3 int c int d </pre> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Note that indicator switching is over-modelled here. Costs of opening a mine do not vary from year 2 to year 3, and are payable only once. So only one indicator is needed for each of C and D. Simpler modelling allowed, see below.</p> </div>	<p>M1 A1</p> <p>M1 A1</p> <p>M1 A1</p> <p>M1 A1 A1</p> <p>M1 A1</p> <p>M1 A1</p> <p>B1</p>	<p>mining</p> <p>opening</p> <p>requirements</p> <p>indicator switching for C for D</p> <p>quality</p> <p>availabilities</p> <p>integer variables</p>

Question	Answer	Marks	Guidance																																										
	<p>OBJECTIVE FUNCTION VALUE</p> <p>1) 0.6745000E+08</p> <table border="0"> <thead> <tr> <th>VARIABLE</th> <th>VALUE</th> </tr> </thead> <tbody> <tr><td>C2</td><td>1.000000</td></tr> <tr><td>C3</td><td>1.000000</td></tr> <tr><td>D2</td><td>0.000000</td></tr> <tr><td>D3</td><td>0.000000</td></tr> <tr><td>C</td><td>1.000000</td></tr> <tr><td>D</td><td>0.000000</td></tr> <tr><td>XA1</td><td>0.000000</td></tr> <tr><td>XA2</td><td>375.000000</td></tr> <tr><td>XA3</td><td>250.000000</td></tr> <tr><td>XB1</td><td>600.000000</td></tr> <tr><td>XB2</td><td>350.000000</td></tr> <tr><td>XB3</td><td>0.000000</td></tr> <tr><td>XC2</td><td>125.000000</td></tr> <tr><td>XC3</td><td>500.000000</td></tr> <tr><td>XD2</td><td>0.000000</td></tr> <tr><td>XD3</td><td>0.000000</td></tr> <tr><td>XA</td><td>625.000000</td></tr> <tr><td>XB</td><td>950.000000</td></tr> <tr><td>XC</td><td>625.000000</td></tr> <tr><td>XD</td><td>0.000000</td></tr> </tbody> </table> <div data-bbox="846 730 1189 922" style="border: 1px solid black; padding: 5px; width: fit-content; margin-left: auto; margin-right: auto;"> <p>Interpretation needed: cost (£67.5m) what is produced where and when what is opened</p> </div>	VARIABLE	VALUE	C2	1.000000	C3	1.000000	D2	0.000000	D3	0.000000	C	1.000000	D	0.000000	XA1	0.000000	XA2	375.000000	XA3	250.000000	XB1	600.000000	XB2	350.000000	XB3	0.000000	XC2	125.000000	XC3	500.000000	XD2	0.000000	XD3	0.000000	XA	625.000000	XB	950.000000	XC	625.000000	XD	0.000000	<p>B1</p> <p>B1</p> <p>B1</p> <p>B1</p>	<p>submitting</p> <p>cost (cao) 8 production location</p>
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		<p>Simpler LP formulation.</p> <p>min $30000A1 + 33000A2 + 35000A3 + 28000B1 + 31000B2 + 33000B3$ $+ 27000C2 + 29000C3 + 28000D2 + 30000D3 + 800000XC +$ $1400000XD$</p> <p>S.T. $A1 + A2 + A3 \leq 650$ $B1 + B2 + B3 \leq 950$ $C2 + C3 \leq 625$ $D2 + D3 \leq 840$ $A1 + B1 \geq 600$ $A2 + B2 + C2 + D2 \geq 850$ $A3 + B3 + C3 + D3 \geq 750$ $2A2 + 0.1B2 - C2 - 1.9D2 \geq 0$ $2A3 + 0.1B3 - C3 - 1.9D3 \geq 0$ $C2 + C3 - 1000XC \leq 0$ $D2 + D3 - 1000XD \leq 0$</p> <p>END INT XC INT XD</p>	[18]																									
3	(i)	<table> <thead> <tr> <th>Month</th> <th>Inflation</th> <th>Committee</th> </tr> </thead> <tbody> <tr> <td>June</td> <td>3.74</td> <td>-1.24</td> </tr> <tr> <td>July</td> <td>2.93</td> <td>-0.43</td> </tr> <tr> <td>August</td> <td>1.69</td> <td>+0.81</td> </tr> <tr> <td>September</td> <td>1.26</td> <td>+1.24</td> </tr> <tr> <td>October</td> <td>2.07</td> <td>+0.43</td> </tr> <tr> <td>November</td> <td>3.31</td> <td>-0.81</td> </tr> <tr> <td>December</td> <td>3.74</td> <td>-1.24</td> </tr> </tbody> </table> <p>... thence cycling.</p>	Month	Inflation	Committee	June	3.74	-1.24	July	2.93	-0.43	August	1.69	+0.81	September	1.26	+1.24	October	2.07	+0.43	November	3.31	-0.81	December	3.74	-1.24	M1 A1 B1 [3]	
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Question		Answer	Marks	Guidance
3	(ii)	3.74	3.74	B1 B1 B1 B1 [4]
		2.93	2.93	
		2.31	2.775	
		2.095	2.72125	
		2.19	2.686875	
		2.3925	2.659219	
		2.5475	2.635859	
		2.60125	2.615957	
		2.5775	2.598975	
		2.526875	2.58448	
		2.488125	2.572108	
		2.474688	2.561548	
		2.480625	2.552535	
		(Oscillatory) convergence in the “half” case Slower, (uniform) convergence on the “one eighth” case		
3	(iii)	$u_{n+2} = u_{n+1} + 0.125 * (2.5 - u_n) \dots$ plus reorganisation	B1 [1]	
3	(iv)	Auxiliary equation ... $x^2 - x + 0.125 = 0$ Solutions ... $(2 \pm \sqrt{2})/4$ General form ... $u_n = A((2 + \sqrt{2})/4)^n + B((2 - \sqrt{2})/4)^n + 2.5$ Simultaneous ... $A + B = 1.24 \dots A((2 + \sqrt{2})/4) + B((2 - \sqrt{2})/4) = 0.43$ Solutions ... $A \approx 0.3513, B \approx 0.8887$	M1 A1 FT M1 A1 FT A1 [5]	
3	(v)	Spreadsheet check Because $((2 + \sqrt{2})/4)^n \rightarrow 0$ and $((2 - \sqrt{2})/4)^n \rightarrow 0$ as n increases	B1 B1 [2]	
3	(vi)	$\alpha = 0.25$ makes discriminant 0 ... (boundary between oscillatory and uniform convergence) spreadsheet fast (uniform) convergence	B1 B1 B1 [3]	

Question		Answer	Marks	Guidance
4	(i)	Lookup tables, or equivalent simulating par 3 simulating par 4 simulating par 5 modelling matchplay	M1 A3 M1 A1 A1 A1 M1 A1 [10]	
4	(ii)	repetition of holes, taking account of pars computing strokeplay result computing matchplay result	M1 A1 B1 B1 [4]	
4	(iii)	repetition of rounds collection and display of results	B1 B1 [2]	
	(iv)	no and no	B1 B1 [2]	Allow follow through

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