



General Certificate of Education

Mathematics 6360

MD02 Decision 2

Mark Scheme

2009 examination - June series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available to download from the AQA Website: www.aqa.org.uk

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Key to mark scheme and abbreviations used in marking

M	mark is for method		
m or dM	mark is dependent on one or more M marks and is for method		
A	mark is dependent on M or m marks and is for accuracy		
B	mark is independent of M or m marks and is for method and accuracy		
E	mark is for explanation		
√ or ft or F	follow through from previous incorrect result	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
-x EE	deduct x marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	dp	decimal place(s)

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

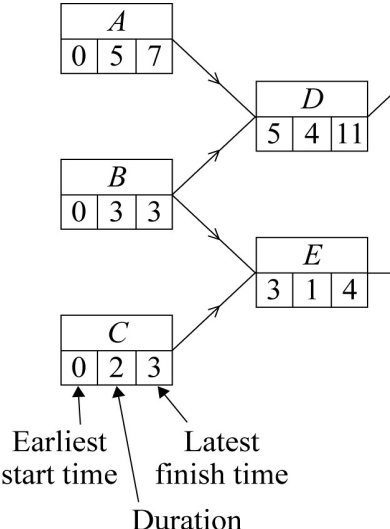
Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

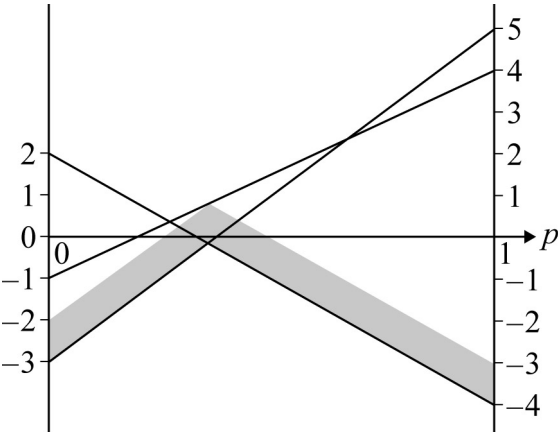
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

MD02

Q	Solution	Marks	Total	Comments
1				
(a)	Network attempted (3 more activities) Up to 2 slips (boxes or connections) Correct network	M1 A1 A1	3	SCA Condone missing arrows if sequence is clear
(b)(i)	Forward pass Correct	M1 A1	2	up to 1 slip ft
(ii)	Backward pass Correct	M1 A1	2	up to 1 slip ft
(c)	Minimum completion time 22 days	B1		Must be stated – not simply in <i>K</i> box
	Critical path <i>B E G H I K</i>	B1	2	and no others
(d)(i)	New start time for <i>H</i> is 15 days New start time for <i>I</i> is 16 days	M1 A1	2	For <i>H</i> , their (<i>F</i> earliest time 9) + (2 + 4) both correct
(ii)	Minimum delay is 2 days	B1	1	Condone new completion time 24 days
	Total		12	

MD02 (cont)

Q	Solution	Marks	Total	Comments
2(a)	(For each outcome) Rowena's gain + Colin's gain = 0	E1	1	One player's loss is other's gain
(b)	(Column maxima 2, 5, 4) ⇒ min(col max)=2 (OE but strict) ⇒ Colin's play-safe strategy is C_1	E1 B1	2	Withhold E mark if any value incorrect; accept column minimax = 2
(c)	R_3 is dominated by R_1	E1	1	$-5 < -4$; $4 < 5$ and $3 < 4$ E0 if R_2 mentioned as well
(d)	Let Rowena play R_1 with prob p and R_2 with prob $1 - p$ Expected gain when Colin plays $C_1 : -4p + 2(1 - p) = 2 - 6p$ $C_2 : 5p - 3(1 - p) = -3 + 8p$ $C_3 : 4p - (1 - p) = -1 + 5p$ Plot expected gains against p for $0 \leq p \leq 1$	M1 A1 M1		attempt at least 2 with one correct all 3 correct unsimplified All 3 drawn ft their exp gains
		A1		correct
	⇒ $2 - 6p = -3 + 8p$	M1		Using "correct" equation Choosing highest point of region
	⇒ $p = \frac{5}{14}$	A1		
	Therefore Rowena plays R_1 with prob $\frac{5}{14}$ and R_2 with prob $\frac{9}{14}$	E1✓	7	ft their p
	Total		11	

MD02 (cont)

Q	Solution	Marks	Total	Comments
3(a)	Hungarian algorithm minimises.	E1	2	Or changes maximising to minimising problem
	$17-x$ gives measure of criteria not met (which need minimising in order to maximise scores)	E1		Explanation of what each new entry or $17-x$ represents (as something which can be minimised)
(b)	$\begin{array}{ccccc} 4 & 4 & 8 & 7 & 4 \\ 4 & 3 & 5 & 0 & 2 \\ 1 & 7 & 9 & 3 & 3 \\ 6 & 3 & 5 & 1 & 7 \\ 5 & 3 & 3 & 4 & 2 \end{array}$	B1	3	array with $17-x$ values
	$\begin{array}{ccccc} 0 & 0 & 4 & 3 & 0 & 0 & 0 & 3 & 3 & 0 \\ 4 & 3 & 5 & 0 & 2 & 4 & 3 & 4 & 0 & 2 \\ 0 & 6 & 8 & 2 & 2 & \rightarrow & 0 & 6 & 7 & 2 & 2 \\ 5 & 2 & 4 & 0 & 6 & 5 & 2 & 3 & 0 & 6 \\ 3 & 1 & 1 & 2 & 0 & 3 & 1 & 0 & 2 & 0 \end{array}$	M1		reduce rows first – condone one slip
		A1		then columns; AG
(c)	Top and bottom rows and 1 st & 4 th columns covered	B1	3	Zeros covered with 2 horizontal and 2 vertical lines
	$\begin{array}{ccccc} 2 & 0 & 3 & 5 & 0 \\ 4 & 1 & 2 & 0 & 0 \\ 0 & 4 & 5 & 2 & 0 \\ 5 & 0 & 1 & 0 & 4 \\ 5 & 1 & 0 & 4 & 0 \end{array}$	M1		augment by subtracting 2 from each uncovered and adding 2 to each double covered – condone one slip (may earn if 4 different lines are drawn)
(d)	T1, R2, V3, U4, S5	M1	4	3 items correctly matched
	T1, U2, V3, S4, R5	A1		First matching correct
		M1		3 items correct in second matching
		A1		Second matching correct and no other matches attempted
(e)	Maximum total score = 74	B1	1	
Total			13	

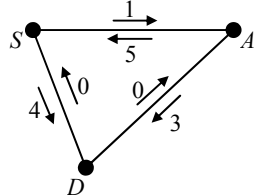
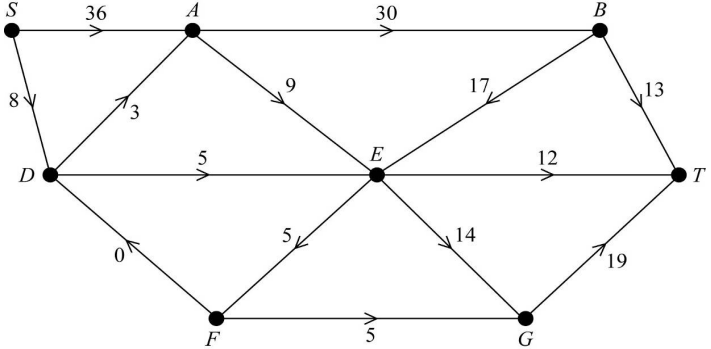
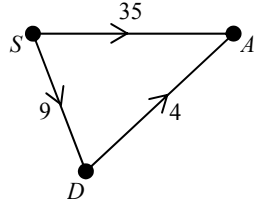
MD02 (cont)

Q	Solution	Marks	Total	Comments																																				
4(a)	$x+2y+3z \leq 7$ $2x+y+4z \leq 10$	B1	1	Exactly this																																				
(b)(i)	Pivot is 2 in x -column	B1		Must be ringed or clearly indicated or stated – not simply implied																																				
	<table border="0"> <tr> <td><i>P</i></td> <td><i>x</i></td> <td><i>y</i></td> <td><i>z</i></td> <td><i>s</i></td> <td><i>t</i></td> <td><i>value</i></td> <td>M1</td> <td></td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>$8-k$</td> <td>0</td> <td>2</td> <td>20</td> <td>A1</td> <td></td> </tr> <tr> <td>0</td> <td>0</td> <td>$1\frac{1}{2}$</td> <td>1</td> <td>1</td> <td>$-\frac{1}{2}$</td> <td>2</td> <td>A1</td> <td>4</td> </tr> <tr> <td>0</td> <td>1</td> <td>$\frac{1}{2}$</td> <td>2</td> <td>0</td> <td>$\frac{1}{2}$</td> <td>5</td> <td></td> <td></td> </tr> </table>	<i>P</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>s</i>	<i>t</i>	<i>value</i>	M1		1	0	1	$8-k$	0	2	20	A1		0	0	$1\frac{1}{2}$	1	1	$-\frac{1}{2}$	2	A1	4	0	1	$\frac{1}{2}$	2	0	$\frac{1}{2}$	5					row operations (even with incorrect pivot) condone one slip Top or 2 nd row correct using correct pivot
<i>P</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>s</i>	<i>t</i>	<i>value</i>	M1																																	
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0	1	$\frac{1}{2}$	2	0	$\frac{1}{2}$	5																																		
(ii)	$8-k < 0$ $\Rightarrow k > 8$	M1 A1	2	Their $f(k) < 0$ SC B1 for $k \geq 9$																																				
(c)(i)	New pivot from z -column in second row	B1 \checkmark		Stated or possibly implied from tableau																																				
	<table border="0"> <tr> <td><i>P</i></td> <td><i>x</i></td> <td><i>y</i></td> <td><i>z</i></td> <td><i>s</i></td> <td><i>t</i></td> <td><i>value</i></td> <td>M1</td> <td></td> </tr> <tr> <td>1</td> <td>0</td> <td>4</td> <td>0</td> <td>2</td> <td>1</td> <td>24</td> <td>A1</td> <td></td> </tr> <tr> <td>0</td> <td>0</td> <td>$1\frac{1}{2}$</td> <td>1</td> <td>1</td> <td>$-\frac{1}{2}$</td> <td>2</td> <td>A1</td> <td>4</td> </tr> <tr> <td>0</td> <td>1</td> <td>$-2\frac{1}{2}$</td> <td>0</td> <td>-2</td> <td>$1\frac{1}{2}$</td> <td>1</td> <td></td> <td></td> </tr> </table>	<i>P</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>s</i>	<i>t</i>	<i>value</i>	M1		1	0	4	0	2	1	24	A1		0	0	$1\frac{1}{2}$	1	1	$-\frac{1}{2}$	2	A1	4	0	1	$-2\frac{1}{2}$	0	-2	$1\frac{1}{2}$	1					row operations using “their” correct pivot condone 1 slip one row (other than pivotal row) correct all correct (condone multiples of rows)
<i>P</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>s</i>	<i>t</i>	<i>value</i>	M1																																	
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0	1	$-2\frac{1}{2}$	0	-2	$1\frac{1}{2}$	1																																		
(ii)	$P = 24$	B1 \checkmark		Provided no negatives in top row																																				
	Optimum now reached	E1		Or $P_{\max} = \dots$																																				
	$x = 1, y = 0, z = 2$	B1 \checkmark		Only ft if no more than 2 slips in final tableau																																				
			3																																					
	Total		14																																					

MD02 (cont)

Q	Solution	Marks	Total	Comments																																																																																															
5(a)	Completing stage 2 values (condone unsimplified)	B1	7																																																																																																
	At least 6 values at stage 3 using only "their" max <i>I</i> value from stage 2 All stage 3 values correct	M1 m1 A1																																																																																																	
5(a)	Using only max at <i>D, E, F, G</i> from stage 3 in stage 4 (at least 3 of these values used) All stage 4 values correct	M1 A1	7																																																																																																
	All stage 5 values correct and all other values correct unsimplified	A1CSO																																																																																																	
				<table border="1"> <thead> <tr> <th>Stage</th> <th>State</th> <th>From</th> <th>Value</th> <th></th> </tr> </thead> <tbody> <tr> <td rowspan="2">1</td> <td><i>K</i></td> <td><i>T</i></td> <td>7</td> <td></td> </tr> <tr> <td><i>L</i></td> <td><i>T</i></td> <td>8</td> <td></td> </tr> <tr> <td rowspan="3">2</td> <td><i>H</i></td> <td><i>K</i></td> <td>$-2 + 7 = 5$</td> <td></td> </tr> <tr> <td rowspan="2"><i>I</i></td> <td><i>K</i></td> <td>$4 + 7 = 11$</td> <td>*</td> </tr> <tr> <td><i>L</i></td> <td>$-1 + 8 = 7$</td> <td></td> </tr> <tr> <td rowspan="4">3</td> <td rowspan="2"><i>J</i></td> <td><i>L</i></td> <td>$5 + 8 = 13$</td> <td></td> </tr> <tr> <td><i>D</i></td> <td><i>H</i></td> <td>$4 + 5 = 9$</td> <td></td> </tr> <tr> <td rowspan="2"><i>I</i></td> <td>$2 + 11 = 13$</td> <td>*</td> </tr> <tr> <td><i>E</i></td> <td><i>H</i></td> <td>$7 + 5 = 12$</td> <td>*</td> </tr> <tr> <td rowspan="3">4</td> <td rowspan="2"><i>I</i></td> <td>$-9 + 11 = 2$</td> <td></td> </tr> <tr> <td><i>F</i></td> <td><i>I</i></td> <td>$-4 + 11 = 7$</td> <td></td> </tr> <tr> <td rowspan="2"><i>J</i></td> <td>$9 + 13 = 22$</td> <td>*</td> </tr> <tr> <td rowspan="2"><i>G</i></td> <td><i>I</i></td> <td>$-7 + 11 = 4$</td> <td></td> </tr> <tr> <td rowspan="2"><i>J</i></td> <td>$-8 + 13 = 5$</td> <td>*</td> </tr> <tr> <td rowspan="3">5</td> <td rowspan="2"><i>A</i></td> <td><i>D</i></td> <td>$-2 + 13 = 11$</td> <td></td> </tr> <tr> <td><i>E</i></td> <td>$5 + 12 = 17$</td> <td>*</td> </tr> <tr> <td rowspan="2"><i>F</i></td> <td>$-8 + 22 = 14$</td> <td></td> </tr> <tr> <td rowspan="2"><i>B</i></td> <td><i>E</i></td> <td>$-1 + 12 = 11$</td> <td></td> </tr> <tr> <td rowspan="2"><i>F</i></td> <td>$-7 + 22 = 15$</td> <td>*</td> </tr> <tr> <td rowspan="2"><i>G</i></td> <td>$-3 + 5 = 2$</td> <td></td> </tr> <tr> <td rowspan="3">5</td> <td rowspan="2"><i>C</i></td> <td><i>G</i></td> <td>$5 + 5 = 10$</td> <td></td> </tr> <tr> <td><i>A</i></td> <td>$1 + 17 = 18$</td> <td>*</td> </tr> <tr> <td><i>B</i></td> <td>$2 + 15 = 17$</td> <td></td> </tr> <tr> <td><i>C</i></td> <td>$6 + 10 = 16$</td> <td></td> </tr> </tbody> </table>	Stage	State	From	Value		1	<i>K</i>	<i>T</i>	7		<i>L</i>	<i>T</i>	8		2	<i>H</i>	<i>K</i>	$-2 + 7 = 5$		<i>I</i>	<i>K</i>	$4 + 7 = 11$	*	<i>L</i>	$-1 + 8 = 7$		3	<i>J</i>	<i>L</i>	$5 + 8 = 13$		<i>D</i>	<i>H</i>	$4 + 5 = 9$		<i>I</i>	$2 + 11 = 13$	*	<i>E</i>	<i>H</i>	$7 + 5 = 12$	*	4	<i>I</i>	$-9 + 11 = 2$		<i>F</i>	<i>I</i>	$-4 + 11 = 7$		<i>J</i>	$9 + 13 = 22$	*	<i>G</i>	<i>I</i>	$-7 + 11 = 4$		<i>J</i>	$-8 + 13 = 5$	*	5	<i>A</i>	<i>D</i>	$-2 + 13 = 11$		<i>E</i>	$5 + 12 = 17$	*	<i>F</i>	$-8 + 22 = 14$		<i>B</i>	<i>E</i>	$-1 + 12 = 11$		<i>F</i>	$-7 + 22 = 15$	*	<i>G</i>	$-3 + 5 = 2$		5	<i>C</i>	<i>G</i>	$5 + 5 = 10$		<i>A</i>	$1 + 17 = 18$	*	<i>B</i>	$2 + 15 = 17$		<i>C</i>	$6 + 10 = 16$	
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(b)	Maximum profit £18m Sequence of actions <i>SAEHKT</i>	B1 B1	2	condone 18																																																																																															
	Total		9																																																																																																

MD02 (cont)

Q	Solution	Marks	Total	Comments										
6(a)	Value of cut = $30 - 10 + 12 + 20 = 52$	M1 A1	2	Full marks for correct answers without working										
(b)	$AE = 9;$ $EF = 5;$ $FG = 4$	B1 B1 B1	3											
(c)(i)	Attempt at forward and backward flows SA 2 & 4; AB 1 & 3; BT 1 & 3 SD 3 & 1; DA 0 & 3; AE 0 & 3 BE 0 & 7; DE 2 & 0; ET 1 & 3 FD 2 & 1; EF 5 & 1; EG 1 & 5 FG 1 & 2; GT 3 & 0	M1 A1 A1	3	At least 5 pairs correct 10 pairs correct all correct										
(ii)	First flow augmenting path and correct flow on table Table correct Adjusting flows – forward and back Correct	M1 A1 M1 A1	4	May end up with  <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Path</th> <th>Extra flow</th> </tr> </thead> <tbody> <tr> <td>$SABT$</td> <td>1</td> </tr> <tr> <td>$SADET$</td> <td>1</td> </tr> <tr> <td>$SDFGT$</td> <td>1</td> </tr> <tr> <td>$SDEGT$</td> <td>1</td> </tr> </tbody> </table> <p style="text-align: right;">Or $SDET$</p>	Path	Extra flow	$SABT$	1	$SADET$	1	$SDFGT$	1	$SDEGT$	1
Path	Extra flow													
$SABT$	1													
$SADET$	1													
$SDFGT$	1													
$SDEGT$	1													
(d)	Max flow of 44 shown on figure 5 	M1 A1	2	up to 2 slips all correct May have 										
(e)	Cut through their saturated arcs Cut passes through AB, AE, DE and DF	M1 A1	2	Or $BT, ET, EG,$ and FG										
Total			16											
TOTAL			75											