



**General Certificate of Education**

**Mathematics 6360**

**MD02      Decision 2**

**Mark Scheme**

*2009 examination - January 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.

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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)	Reducing columns: $\begin{array}{ccccc} 7 & 9 & 7 & 4 & 5 \\ 9 & 7 & 6 & 5 & 3 \\ 3 & 5 & 4 & 1 & 0 \\ 3 & 2 & 3 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 \end{array}$	M1		Reducing columns (allow up to 2 slips)
	Reducing rows: $\begin{array}{ccccc} 3 & 5 & 3 & 0 & 1 \\ 6 & 4 & 3 & 2 & 0 \\ 3 & 5 & 4 & 1 & 0 \\ 3 & 2 & 3 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 \end{array}$	A1	3	All correct  AG
(b)	$\begin{array}{ccc c c} x & x & x & & \\ x & x & x & & \\ x & x & x & & \\ x & x & x & & \\ \hline & & & & \end{array}$			
	Covering with 3 lines as above	B1		
	Subtracting 2 from uncovered entries <b>and</b> adding 2 to double covered entries	M1		Condone one slip
	$\begin{array}{ccccc} 1 & 3 & 1 & 0 & 1 \\ 4 & 2 & 1 & 2 & 0 \\ 1 & 3 & 2 & 1 & 0 \\ \hline 1 & 0 & 1 & 0 & 1 \\ \hline 0 & 0 & 0 & 3 & 3 \end{array}$	A1		Correct table
	Can be covered with 4 lines, so reduce uncovered entries by 1 and increase double covered entries by 1	m1		Condone one further slip
	$\begin{array}{ccccc} 0 & 2 & 0 & 0 & 1 \\ 3 & 1 & 0 & 2 & 0 \\ 0 & 2 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 & 2 \\ 0 & 0 & 0 & 4 & 4 \end{array}$	A1	5	CSO
(c)	S – 1, Q – 4 P3, Q4, R5, S1, T2 P5, Q4, R2, S1, T3	M1 A1 A1	3	First correct match 1S, 2T, 3P, 4Q, 5R Second match 1S, 2R, 3T, 4Q, 5P
(d)	Minimum time is $13 + 13 + 12 + 17 + 15 = 70$	B1	1	Or $10 + 13 + 18 + 17 + 12 = 70$
	<b>Total</b>		<b>12</b>	

MD02 (cont)

Q	Solution	Marks	Total	Comments
2(a)				
(i)	Earliest start times	M1 A1	2	Condone one slip with FT All correct
(ii)	Latest finish times	M1 A1	2	Condone one slip with FT All correct
(b)	Critical paths <i>BEHJ</i> <i>BDFIJ</i> Minimum completion time 22 days	B1 B1 B1	3	And no others
(c)(i)	<i>BEHJ</i> or <i>BDFIJ</i> correctly fitted  Second of critical paths A and C shown correctly F and G shown correctly no gaps in blocks etc	B1  B1 B1 B1	4	Withhold first B1 mark if activities not clearly indicated
(ii)	Problem with C - now starts day 5 E delayed until day 7 E delayed until day 7 F cannot start until day 14 (H, I and J delayed) Extra time required 5 days	E1  E1 B1	3	Or C starts day 12 and F starts day 14
	<b>Total</b>		<b>14</b>	

## MD02 (cont)

Q	Solution	Marks	Total	Comments
<b>3(a)</b>	$  \begin{array}{ccccccc}  P & x & y & z & r & s & \text{Value} \\  1 & -4 & 5 & -6 & 0 & 0 & 0 \\  0 & 6 & 7 & -4 & 1 & 0 & 30 \\  0 & \textcircled{2} & 4 & -5 & 0 & 1 & 8  \end{array}  $	B1 B1 B1	3	B0 if no slack variables used
<b>(b)(i)</b>	Both negative when each value is divided by the entry in $z$ -column	E1	1	
<b>(ii)</b>	Pivot from $x$ -column since value in top row is negative  $\frac{30}{6} = 5, \frac{8}{2} = 4$ and $4 < 5$  Choose $\textcircled{2}$ as pivot	E1 B1	2	Both calculations and comparison needed
<b>(iii)</b>	$  \begin{array}{ccccccc}  1 & 0 & 13 & -16 & 0 & 2 & 16 \\  0 & 0 & -5 & 11 & 1 & -3 & 6 \\  0 & 1 & 2 & -2\frac{1}{2} & 0 & \frac{1}{2} & 4  \end{array}  $	M1 A1 A1	3	Row operations keeping pivot row fixed or divided by 2 First or second row correct  All correct (final row may be 0 2 4 -5 0 1 8)
<b>(iv)</b>	$x = 4$ $y = 0, z = 0$	B1 B1	2	
<b>(v)</b>	As $z$ increases, $P$ increases without limit	E1	1	
<b>(c)(i)</b>	New initial tableau  $  \begin{array}{ccccccc}  Q & x & y & z & r & s & \text{Value} \\  1 & - & 5 & \textcircled{20} & 0 & 0 & 0 \\  0 & 6 & 7 & -4 & 1 & 0 & 30 \\  0 & 2 & 4 & -5 & 0 & 1 & 8  \end{array}  $ Revised tableau after one iteration $  \begin{array}{ccccccc}  1 & 0 & 13 & \textcircled{10} & 0 & 2 & 16  \end{array}  $	B1 B1 $\checkmark$	2	Top row only changed to exactly this
<b>(ii)</b>	Max $Q = 16$	B1	1	
<b>Total</b>			<b>15</b>	

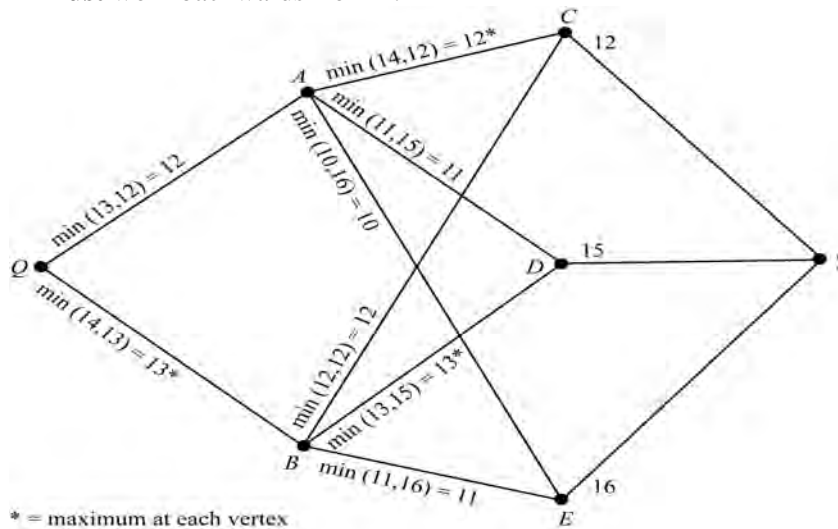
## MD02 (cont)

Q	Solution	Marks	Total	Comments
4(a)	<p>Row minima  <math>-7</math>  <math>-1</math>  <math>-3</math></p> <p>Column max <math>6 \quad 8 \quad -1</math></p> <p>Max (row min) = <math>-1</math></p> <p>Min (col max) = <math>-1</math></p> <p>Since these values are equal the game has a stable solution</p> <p>Raj plays II, Cal plays Z</p>	M1 A1 E1 B1	4	<p>Attempting Row Min &amp; Col Max or Maxmin and Minmax</p> <p>All values correct and shown with correct words</p> <p>Must both be <math>-1</math> and have statement</p>
(b)(i)	<p><math>C_1 : 5p - 2(1 - p)</math></p> <p><math>C_2 : xp + 4(1 - p)</math></p>	B1 B1	2	$7p - 2$
(ii)	<p>Value of game = <math>\frac{8}{3}</math></p> <p><math>\Rightarrow 5p - 2(1 - p) = \frac{8}{3}</math></p> <p><math>\Rightarrow p = \frac{2}{3}</math></p> <p><math>xp + 4(1 - p) = \frac{8}{3}</math></p> <p><math>\Rightarrow \frac{2}{3}x + \frac{4}{3} = \frac{8}{3}</math></p> <p><math>\Rightarrow x = 2</math></p>	M1 A1 M1 A1	4	<p>Their expected gain (<math>C_1</math>) = <math>\frac{8}{3}</math></p> <p>Their <math>C_2</math> gain = <math>\frac{8}{3}</math> (must involve <math>x</math>)</p>
	<b>Total</b>		<b>10</b>	

MD02 (cont)

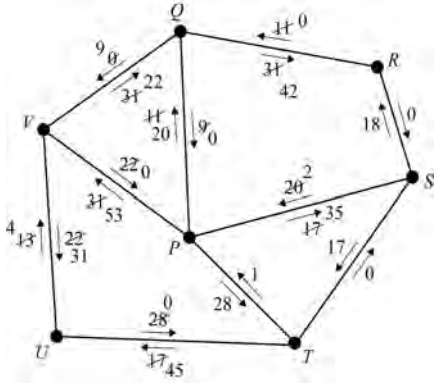
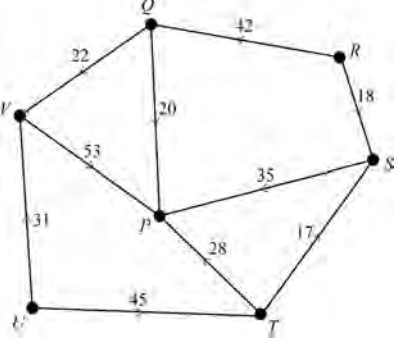
Q	Solution					Marks	Total	Comments
5(a)	Greatest load on <i>QACY</i> is 12 tonnes and on <i>QBEY</i> is 11 tonnes					M1	2	Either 12 or 11 stated
	<i>QACY</i> allows greater load to be carried					A1		Both 12 and 11 seen plus statement
(b)	Stage	State	Action	Calculation	Value			
	1	C	CY	-	12	B1	Stage 1 values (12), 15 and 16	
			DY	-	15			
			EY	-	16			
	2	A	AC	Min(14,12)	12*	M1 A1 A1	Stage 2: at least 3 min values correct At least 5 values correct All calculations showing minima and values correct	
			AD	Min(11,15)	11			
			AE	Min(10,16)	10			
		B	BC	Min(12,12)	12			
			BD	Min(13,15)	13*			
			BE	Min(11,16)	11			
	3	Q	QA	Min(13,12)	12	m1	Stage 3: "12" and "13" brought forward from Stage 2	
			QB	Min(14,13)	13*			
	Maximin route <i>QBDY</i>					B1	8	All calculations and values correct
Maximum possible load = 13 tonnes					B1			
<b>Total</b>						<b>10</b>		

Network approach – **must** work backwards from Y:





MD02 (cont)

Q	Solution	Marks	Total	Comments																
6(a)	Arrival gates are <i>U</i> and <i>R</i>	B1	1																	
(b)	Cut value = $45 + 53 + 20 + 37 + 0$ = 155	B1	1																	
(c)	Max flow along <i>UTSP</i> is 17 and along <i>RQVP</i> is 31	B1 B1	2																	
(d)(i)	 <table border="1" data-bbox="908 573 1321 855"> <thead> <tr> <th>Route</th> <th>Value of Flow</th> </tr> </thead> <tbody> <tr> <td><i>UTSP</i></td> <td>17</td> </tr> <tr> <td><i>RQVP</i></td> <td>31</td> </tr> <tr> <td><i>RSP</i></td> <td>18</td> </tr> <tr> <td><i>RQP</i></td> <td>11</td> </tr> <tr> <td><i>UTP</i></td> <td>28</td> </tr> <tr> <td><i>UVP</i></td> <td>22</td> </tr> <tr> <td><i>UVQP</i></td> <td>9</td> </tr> </tbody> </table> <p>Initial flows along <i>UTSP</i> and <i>RQVP</i> with potential increases and decreases</p> <p>Table: first route and correct flow Another route and flow Table correct</p> <p>Network: attempt to use labelling procedure with forward/backward flows All diagram correct</p>	Route	Value of Flow	<i>UTSP</i>	17	<i>RQVP</i>	31	<i>RSP</i>	18	<i>RQP</i>	11	<i>UTP</i>	28	<i>UVP</i>	22	<i>UVQP</i>	9	B1 M1 A1 A1 M1 A1	6	After <i>UTSP</i> and <i>RQVP</i>
Route	Value of Flow																			
<i>UTSP</i>	17																			
<i>RQVP</i>	31																			
<i>RSP</i>	18																			
<i>RQP</i>	11																			
<i>UTP</i>	28																			
<i>UVP</i>	22																			
<i>UVQP</i>	9																			
(ii)	Maximum flow = 136 Figure 5 correct:	B1																		
		B1	2	Other possible answers																
(e)	Rate reduced by 3 New maximum is 133	M1 A1	2	“their” maximum flow – 3																
	<b>Total</b>		<b>14</b>																	
	<b>TOTAL</b>		<b>75</b>																	