Version 1.0

**General Certificate of Education (A-level)
January 2012**

Mathematics   **MD02**

(Specification 6360)

Decision 2

Final

Mark Scheme

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 events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised 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 students' 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.

Key to mark scheme abbreviations

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
CAO	correct answer only
CSO	correct solution only
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
A2,1	2 or 1 (or 0) accuracy marks
$-x$ EE	deduct x marks for each error
NMS	no method shown
PI	possibly implied
SCA	substantially correct approach
c	candidate
sf	significant figure(s)
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.

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.

Q	Solution	Marks	Total	Comments
1(a)	$x = 4$	B1		
	$y = 12$	B1		
	$z = 13$	B1	3	
(b)	$B\,D\,H\,J$ and $C\,E\,I\,J$	M1		first correct path
		A1	2	2nd correct and no others
(c)	G	B1		
	Float = 3	B1	2	
(d)	One of their CPs correct height	M1		and correct durations
	B, D, H, J and C, E, I correct	A1		and correct durations

Q	Solution	Marks	Total	Comments
	A starting at 0 and ending at 3	M1		one correct with correct height
	F starting at 6 and ending at 11	A1		two correct with correct height
	G starting at 13 and ending at 14	A1	5	all correct with correct height
				withhold first A1 earned if it is not clear which activities take place at any given time
				withhold another A1 if "holes" appear in histogram
(e)	New earliest J 22 days	B1		assuming activities continuous
	Minimum extra time 5 days	B1	2	assuming activities continuous
	Total		**14**	

Q	Solution	Marks	Total	Comments
2(a)	Hungarian algorithm used to find **minimum total**	E1		First E1– fairly generous for idea of "minimising"
	Each new entry gives measure of points **not** scored	E1		or "points not scored". Second E1 is strict.
	$\Rightarrow$ Hungarian algorithm now finds maximum total score		2	
(b)	Replacing x by $35 - x$ 8 6 10 0 4 2 13 18 6 6 12 6 10 2 14 13 6 6 8 4 8 8 16 14 8	B1		Must see this table
	8 6 10 0 4 0 11 16 4 4 10 4 8 0 12 9 2 2 4 0 0 0 8 6 0	M1		reducing rows; ft one slip from above & allow one further slip
	8 6 8 0 4 0 11 14 4 4 10 4 6 0 12 9 2 0 4 0 0 0 6 6 0	A1cso	3	check working is correct since most values in final table are given. ($p = 14$ $q = 9$)
(c)	Lines covering R_4 , R_5 and C_1 , C_4	B1		4 correct lines
	8 2 4 0 0 0 7 10 4 0 10 0 2 0 8 13 2 0 8 0 4 0 6 10 0	M1 A1	 3	subtracting 4 from each uncovered and adding 4 to each double covered (condone 2 slips) all correct
(d)(i)	B1 and D3	M1		or one **full** matching with rings etc
	A4 B1 C2 D3 E5 A5 B1 C4 D3 E2	A1 A1	 3	one correct matching second correct and no others
(ii)	Total = 153	B1	1	
	Total		**12**	

Q	Solution	Marks	Total	Comments
3(a)	**For each pair of strategies** Roz gain + Colum gain = 0	E2,1	2	E1 for general idea of Roz gain + Colum gain = 0
(b)	Colum's max are $-2, 3, -1$ min (colum max) $= -2$ $\Rightarrow$ play safe is C_1	E1 B1	2	must see these values for E1
(c)(i)	Delete R_2 (PI by further work) Since R_3 dominates R_2	M1 A1	2	$\begin{array}{ccc} C_1 & C_2 & C_3 \\ -2 & -6 & -1 \quad R_1 \\ -3 & 3 & -4 \quad R_3 \end{array}$
(ii)	Let Roz play R_1 with prob p C_1 expected gain: $-2p - 3(1-p) = p - 3$ $C_2 : -6p + 3(1-p) = 3 - 9p$ $C_3 : -p - 4(1-p) = 3p - 4$	M1 A1		2 expressions unsimplified ft their matrix all correct
		M1 A1		plotting 3 expected gains for $0 \leqslant p \leqslant 1$ correct gains plotted accurately
	Solving $p - 3 = 3 - 9p$ $\Rightarrow 10p = 6$ $p = \frac{3}{5}$ $\Rightarrow$ Roz plays R_1 with probability $\frac{3}{5}$ and R_3 with probability $\frac{2}{5}$	m1 A1 E1cao	7	choosing highest point of 'their' region or correct pair solved must see R_1 and R_3
	Total		**13**	

Q	Solution	Marks	Total	Comments
4(a)(i)	x-column	B1		
	pivot $= 6$	B1		
	$\dfrac{2}{2} = 1$, $\dfrac{3}{6} = \dfrac{1}{2}$ $\left(\text{and } \dfrac{1}{2} < 1 \right)$			need to see correct quotients considered
	smallest **positive** quotient	E1	3	negative value **must** be mentioned as being considered but rejected
(ii)	$\begin{array}{ccccccc} P & x & y & z & s & t & u & \text{value} \\ 1 & 0 & 1 & 0 & 1 & \frac{1}{3} & 0 & 7 \end{array}$	M1		row operations
	$\begin{array}{cccccccc} 0 & 0 & 13 & 1 & 3 & -\frac{1}{3} & 0 & 1 \end{array}$	A1		1st, 2nd or 4th row correct
	$\begin{array}{cccccccc} 0 & 1 & -5 & 0 & -1 & \frac{1}{6} & 0 & \frac{1}{2} \end{array}$	A1		another of these 3 correct
	$\begin{array}{cccccccc} 0 & 0 & -14 & 0 & -4 & \frac{1}{6} & 1 & 4\frac{1}{2} \end{array}$	A1	4	all correct (condone multiples of rows)
(b)(i)	No negatives in **top row**	E1	1	**but** must have no negative values in "their" top row
(ii)	One (inequality still has slack)	B1	1	
(c)(i)	$P = 7$	B1✓		FT their tableau
	$x = \dfrac{1}{2}$, $y = 0$, $z = 1$	B1 cao	2	condone one slip in final tableau
(ii)	Substituting "their" values from (c) (i)			
	$\dfrac{1}{2} k + 0 + 3 = 7$	M1		
	$\Rightarrow k = 8$	A1	2	
			13	

Q	Solution					Marks	Total	Comments
5(a)	**Stage**	**State**	**From**	**Calculation**				
	1	G	T		15			
		H	T		17	B1		stage 1 correct
		I	T		26			
	2	D	G	6 + 15	21 ←			
			H	3 + 17	20			
		E	G	–3 + 15	12	M1		7 values at stage 2 attempted
			H	–6 + 17	11			with 5 unsimplified calculations correct
			I	–13 + 26	13 ←			
		F	H	–7 + 17	10			
			I	–14 + 26	12 ←	A1		stage 2 correct
	3	A	D	–4 + 21	17	M1		use of two of "their" maxima from
			E	6 + 13	19 ←			Stage 2 to Stage 3
		B	D	12 + 21	33 ←			
			E	16 + 13	29			
			F	18 + 12	30			
		C	E	14 + 13	27 ←			
			F	13 + 12	25	A1		stage 3 correct
	4	S	A	12 + 19	31*			
			B	–2 + 33	31*			
			C	3 + 27	30	A1cso	6	stage 4 & all other values correct
(b)	Maximum profit = 31					B1√		£31 million
	$S\,A\,E\,I\,T$ and $S\,B\,D\,G\,T$					B1		one correct path
						B1	3	second correct path and no other
					Total		**9**	

Q	Solution			Marks	Total	Comments
6(a)	$10 + 13 - 1 + 17$			M1		3 values added and -1 (condone one slip)
	$= 39$			A1	2	
(b)(i)	*DE* 12			B1		on Figure 2
	FG 7			B1	2	
(ii)	**arc**	**forward**	**backward**			
	SA	3	1			
	AB	1	1			
	BT	0	1			
	SC	0	2			
	CA	0	1			
	AD	0	1			
	CD	1	1			
	DE	1	2			
	BE	1	3	M1		at least 6 pairs correct on Figure 3
	ET	2	3			(must have arrows)
	SF	1	1			
	FC	1	2			
	FD	1	0			
	FG	0	1	A1	2	all correct
	DG	2	1			
	EG	1	1			
	GT	2	3			
(iii)	**Table**					

Path	Extra Flow
SABET	1
SFDGT	1
SACDGT	1

M1 — 1 correct path and extra flow

A1 — all correct

DEG triangle may have different flows with implications to triangle GET.

Network

	M1		1 path correctly augmented forward and backward
			but must have earned M1 in part (b)(ii)
	A1	4	network correct
(c)(i) Max flow $= 37$	B1	1	

Q	Solution	Marks	Total	Comments
6(c) cont. **(ii)**	Max flow	B2		correct flow of 37
				condone 2 slips or omissions in flow of 37 **or** "correct" feasible flow of 36 for SC1
			2	
(d)	Cut through *AB*, *AD*, *CD, FD* and *FG*	B1	1	$\{ S, A, C, F \} \{ B, D, E, G, T \}$
	Total		**14**	
	TOTAL		**75**	