

General Certificate of Education June 2010

Mathematics

MDO₂

Decision 2

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 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.

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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								
В	mark is independent of M or m marks and is for method and accuracy								
Е	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				lark Scheme 2010 June serie
Q	Solution	Marks	Total	Comments
1(a)	B E H 8 6 14	J 6 2 19 K 4 5 19	19	<u>L</u> 2 21
(b)	Earliest start times Latest finish times Critical paths are <i>AEHKL</i> and <i>BFHKL</i>	M1 A1 M1 A1 M1	4	one slip follow through all correct one slip follow through all correct one correct both correct and no
	Minimum completion time = 21 days	B1	3	extras
(c)	D A E G B F H K L D Days			$A(0 \to 4)$ $B(0 \to 3)$ $C(0 \to 2 \to 3)$ $D(4 \to 7 \to 9)$ $E(4 \to 8)$ $F(3 \to 8)$ $G(8 \to 16 \to 17)$ $H(8 \to 14)$ $I(8 \to 10 \to 14)$ $I(16 \to 18 \to 19)$ $K(14 \to 19)$ $L(19 \to 21)$
		B1		A, B, E, F, H, K, L
		M1		correct <i>C</i> , <i>D</i> , <i>G</i> , <i>I</i> , <i>J</i>
		A1	3	(4 with correct start and duration) All 5 correct with correct slack indicated
(d)(i)	K now starts day 17	B1		or "delayed" b 3
	L now starts day 22	B1	2	days if 14 in network or "delayed" b 3
(ii)	Overall delay 3 days	B1	1	days if 19 in network
	Total		13	

MID02 (cont	<u>) </u>					1	1	
Q			Solut	tion		Marks	Total	Comments
2(a)								
	2	4	0	5	5			
	4	2	0	4	3	M1		rows reduced (allow one slip)
	5	0	1	9	2			17
	1	1	0	7	4			
	0	2	0	3	5			
	Ŭ	_	Ü		· ·			
	2	4	0	2	3			
	4	2	ő	1	1	m1		columns reduced next
	5	0	1	6	0	1111		Correct table
	1	1	0	4		A1	_	k = 6 stated or correct in table
	0	2	0	0	2 3	111	3	N O Stated of coffeet in table
	U	2	U	U	3			
(b)	3 lines	needeo	d to cove	er zeros s	hown	B1		middle column, middle and bottom rows
								,
	Reduc	e each	uncovere	ed eleme	nt by 1 and			
			le cover		J	M1		Condone one slip
				,				1
	1	3	0	1	2			
	3	1	0	0	2 0			
	5	0	2	6(k)				
	0	0	0	3	1			FT "their k". Condone k instead
	0	2	1	0	3	A 1	3	of 6
	U	2	1	U	3			010
(c)	A3					M1		Or correct "rings" round elements for one
								complete solution
	(A3)	<i>B</i> 4	C5	D2	<i>E</i> 1	A1		first correct matching – must be stated
	(A3)	B5	C2	D1	E4	A1	3	second correct matching and no others
	(213)	DJ	02	ν1	L.	111		second correct materning and no others
(d)	Minin	num tots	al nenalt	y points	= 22	B1	1	
(u)	141111111	16111 1011	ai penari	, points	Total	D1	10	
	l				Total		10	

MD02 (cont	<u>, </u>			C 1	4.		1	3.6 3	7F / 1	
Q				Solu	tion			Marks	Total	Comments
3(a)							,			
	P	X	У	\boldsymbol{z}	S	t	valu	3.61		T 1 1 1 1 1
			_	2	0	•	e	M1		Two slack variables used correctly
	1	-6	-5	-3	0	0	0	A1		1 row correct
	0	(1)	2	-3 <i>k</i> 1	1	0	0 8 17	A1		all correct
	0	2	10	1	0	1	17		3	
										May earn in (b)(i)
(b)(i)	Pivot	ın x-c	olum	n = 1				B1		May be implied by second row
										unchanged
	1	0	7	(1.2	_	0	40	3.7.1		
	1	0	7	6 <i>k</i> –3 <i>k</i> 1–2 <i>k</i>	6	0	48	M1		row operations (even with wrong
	0	1	2	K	1	0	8 1	A1		pivot)
	0	0	6	1-2k	-2	I	1	A1	4	1st or 3rd row correct
										all correct
(ii)	6k-3	2 - 0						M1		"their" $6k - 3 < 0$
(11)	$0\kappa - 3$	><0						IVI I		then $6k-3<0$
				$\Rightarrow k$	< 1			A1	2	
				,	2			111	_	
(c)										
	1	0	7	– 9	6	0	48			
	0	1	2	-1	1	0	8 1			
	0	0	6	-9 -1 3	-2	1	1	M1		new pivot correct from their
								171 1		tableau and row operations
										attempted
										attempted
		_			_	_		A1		2 rows correct (may be multiples of
	1	0	25	0	0	3	51	711		rows) usually pivot row & 1 other
	0	1	4	0	1	1	Q 1			10ws) usuarry prvot fow & 1 other
	0	1	4	0	3	3	$o_{\overline{3}}$	A1	3	all correct (condone multiples of
	0	0	2	1	_2	1	<u>1</u>	711		rows) Condone FT from one slip
	U	U	2	1	3	3	3			in (b)(i)
										III (0)(1)
	M	D	1 .	1				Г1		
	Max I	now	achi	eved				E1		Or "optimum", " $P_{\text{max}} = \dots$ "etc"
										Bur must have no negatives in top
										row
	P = 5	1						B1√		FT their tableau
	v = Q	1 .,_	. 0 ~	_ 1	11+h=	(و و				correct values from almost
	x = 8	$\frac{1}{3}$, y –	U, Z	$-\frac{1}{3}$ (8)	ııı tIII	<i>(</i> 0)		B1	3	'correct' tableau (condone one slip)
										condone 8.33 or better
							Total		15	

C ₂ and C ₃ lines give optimum $4p-1=4-9p$ $p=\frac{5}{13}$ Roger plays $R_1 \frac{5}{13} \text{ of time and } R_2 \frac{8}{13} \text{ of time}$ $M1$ $Value of game = 4 \times \frac{5}{13} - 1 = \frac{7}{13}$ $R_1 : 7p + 3q - 5(1 - p - q)$ $R_2 : -2p - q + 4(1 - p - q)$ $\Rightarrow 12p + 8q = 5 \frac{7}{13}$ M1 $R_1 : \frac{1}{2} \times \frac{1}{2} \times$	Q Q	Solution	Marks	Total	Comments
Expected gains: $C_1:7p-2(1-p)=9p-2$	4(a)(i)	Let Roger play R_1 with probability p and			
$C_1: 7p - 2(1-p) = 9p - 2$ $C_2: 3p - (1-p) = 4p - 1$ $C_3: -5p + 4(1-p) = 4 - 9p$ $A1$ $A1$ $A2$ $A3$ $A4$ $A4$ $A5$ $A4$ $A5$ $A5$ $A5$ $A6$ $A7$ $A1$ $A1$ $A1$ $A1$ $A1$ $A1$ $A1$ $A2$ $A3$ $A4$ $A5$ $A5$ $A4$ $A5$ $A6$ $A7$ $A7$ $A7$ $A7$ $A8$ $A8$ $A9$ $A9$ $A9$ $A9$ $A9$ $A9$ $A9$ $A9$		R_2 with probability $1-p$			
C ₂ : $3p - (1-p) = 4p - 1$ C ₃ : $-5p + 4(1-p) = 4 - 9p$ A1 A1 A1 A1 A1 A1 A1 A1 A1 A		*			
C ₃ : $-5p + 4(1-p) = 4-9p$ A1 A1 A1 A1 A1 A1 A1 A1 A1 A		· , ,	M1		one correct unsimplified
M1 A1 A1 A1 A1 A1 A1 A1 A1 A1 A		$C_2: 3p - (1-p) = 4p - 1$			
all correct and accurate for $0 \le p \le 1$ Condone lines not quite to $p = 1$ if usin "accurate" intersection points on p-axis i.e. $\frac{2}{9} < \frac{1}{4}$ and $\frac{4}{9} \approx twice \frac{2}{9}$ C_2 and C_3 lines give optimum $A_1 = \frac{5}{13}$ $A_1 = \frac{5}{13}$ $A_1 = \frac{5}{13}$ $A_2 = \frac{5}{13}$ $A_3 = \frac{5}{13}$ $A_4 = \frac{5}{13}$ $A_4 = \frac{5}{13}$ $A_4 = \frac{5}{13}$ $A_4 = \frac{7}{13}$ $A_5 = $		$C_3: -5p + 4(1-p) = 4-9p$	A1		all correct unsimplified
all correct and accurate for $0 \le p \le 1$ Condone lines not quite to $p = 1$ if usin "accurate" intersection points on p-axis i.e. $\frac{2}{9} < \frac{1}{4}$ and $\frac{4}{9} \approx twice \frac{2}{9}$ C_2 and C_3 lines give optimum $A_1 = \frac{5}{13}$ $A_1 = \frac{5}{13}$ $A_1 = \frac{5}{13}$ $A_2 = \frac{5}{13}$ $A_3 = \frac{5}{13}$ $A_4 = \frac{5}{13}$ $A_4 = \frac{5}{13}$ $A_4 = \frac{5}{13}$ $A_4 = \frac{7}{13}$ $A_5 = $		7			
all correct and accurate for $0 \le p \le 1$ Condone lines not quite to $p = 1$ if usin "accurate" intersection points on p-axis i.e. $\frac{2}{9} < \frac{1}{4}$ and $\frac{4}{9} \approx twice \frac{2}{9}$ C_2 and C_3 lines give optimum $A_1 = \frac{5}{13}$ $A_1 = \frac{5}{13}$ $A_1 = \frac{5}{13}$ $A_2 = \frac{5}{13}$ $A_3 = \frac{5}{13}$ $A_4 = \frac{5}{13}$ $A_4 = \frac{5}{13}$ $A_4 = \frac{5}{13}$ $A_4 = \frac{7}{13}$ $A_5 = $		4	M1		2 of their lines drawn correctly
C ₂ and C ₃ lines give optimum $4p-1=4-9p$ $p=\frac{5}{13}$ Roger plays $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $M1$ $Value of game = 4 \times \frac{5}{13} - 1 = \frac{7}{13}$ $R_1: 7p + 3q - 5(1-p-q)$ $R_2: -2p - q + 4(1-p-q)$ $\Rightarrow 12p + 8q = 5\frac{7}{13}$ M1 $R_1 = \frac{7}{13} \text{ and } \frac{4}{9} \approx twice^{\frac{2}{9}}$ #A1 #A2 #A2 #A2 #A3 #A4 #A4 #A5 #A6 #A6 #A7 #A7 #A7 #A7 #A7 #A7		3			
C ₂ and C ₃ lines give optimum $4p-1=4-9p$ $p=\frac{5}{13}$ Roger plays $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $M1$ $Value \text{ of game} = 4 \times \frac{5}{13} - 1 = \frac{7}{13}$ $E1$ CAO $E1$ $AG \text{ or } \left(4-9 \times \frac{5}{13}\right) = \frac{7}{13}$ must see correct calculation $R_1: 7p+3q-5(1-p-q)$ $R_2: -2p-q+4(1-p-q)$ $\Rightarrow 12p+8q=5\frac{7}{13}$ $A1$ i.e. $\frac{2}{9} < \frac{1}{4} \text{ and } \frac{4}{9} \approx twice \frac{2}{9}$ if their max point of region Condone 0.385 or 0.3846(15) must be correct rounding if 3sf used $R_1: 7p + 3q = 5(1-p-q)$ $R_2: -2p-q+4(1-p-q)$ $R_3: 12p+8q=5\frac{7}{13}$ A1 ii.e. $\frac{2}{9} < \frac{1}{4} \text{ and } \frac{4}{9} \approx twice \frac{2}{9}$ if their max point of region Condone 0.385 or 0.3846(15) must be correct rounding if 3sf used $R_1: 7p + 3q = 5(1-p-q)$ $R_2: -2p-q+4(1-p-q)$ $R_3: -2p-q+4(1$		1 p			Condone lines not quite to $p = 1$ if using
C ₂ and C ₃ lines give optimum $4p-1=4-9p$ $p=\frac{5}{13}$ Roger plays $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} of time an$		-1 -2			
C ₂ and C ₃ lines give optimum $4p-1=4-9p$ $p=\frac{5}{13}$ Roger plays $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{8}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} \text{ of time}$ $R_1\frac{5}{13} \text{ of time and } R_2\frac{5}{13} of time an$		-5			1.e. $\frac{1}{9} < \frac{1}{4}$ and $\frac{1}{9} \approx twice \frac{1}{9}$
Roger plays $R_{1} \frac{5}{13} \text{ of time and } R_{2} \frac{8}{13} \text{ of time}$ (ii) Value of game = $4 \times \frac{5}{13} - 1 = \frac{7}{13}$ (b) Let Corrie play C_{1} with prob p , C_{2} with prob q , C_{3} with prob $1 - p - q$ $R_{1} : 7p + 3q - 5(1 - p - q)$ $R_{2} : -2p - q + 4(1 - p - q)$ $\Rightarrow 12p + 8q = 5\frac{7}{13}$ A1 Condone 0.385 or 0.3846(15) must 8 correct rounding if 3sf used CAO Hand CAO AG or $\left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ must see correct calculation M1 any correct expression either equation correctly with coefficiency of p and q correctly simplified		C_2 and C_3 lines give optimum			
Roger plays $R_{1} \frac{5}{13} \text{ of time and } R_{2} \frac{8}{13} \text{ of time}$ $R_{1} \frac{5}{13} \text{ of time and } R_{2} \frac{8}{13} \text{ of time}$ $R_{1} \frac{5}{13} \text{ of time and } R_{2} \frac{8}{13} \text{ of time}$ $R_{1} \frac{5}{13} \text{ of time and } R_{2} \frac{8}{13} \text{ of time}$ $R_{1} \frac{5}{13} \text{ of time and } R_{2} \frac{8}{13} \text{ of time}$ $R_{2} \frac{5}{13} - 1 = \frac{7}{13}$ $R_{3} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{4} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{5} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{2} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{3} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{2} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{3} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{4} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{2} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{3} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{4} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{2} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{3} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{2} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{2} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{3} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{1} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{2} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{3} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{4} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{4} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{4} \text{ or } \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ $R_{5} \text{ or } \left$		4p - 1 = 4 - 9p	M1		
Roger plays $R_{1} \frac{5}{13} \text{ of time and } R_{2} \frac{8}{13} \text{ of time}$ E1 7CAO (ii) Value of game = $4 \times \frac{5}{13} - 1 = \frac{7}{13}$ B1 $1 \text{AG} \text{or} \left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ must see correct calculation (b) Let Corrie play C_{1} with prob p , C_{2} with prob q , C_{3} with prob $1 - p - q$ $R_{1}: 7p + 3q - 5(1 - p - q)$ $R_{2}: -2p - q + 4(1 - p - q)$ $\Rightarrow 12p + 8q = 5\frac{7}{13}$ A1 $either equation correctly with coefficient of p and q correctly simplified$		$p=\frac{5}{3}$	A1		Condone 0.385 or 0.3846(15) must be
(ii) Value of game $= 4 \times \frac{5}{13} - 1 = \frac{7}{13}$ B1 1 AG or $\left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ must see correct calculation (b) Let Corrie play C_1 with prob p , C_2 with prob q , C_3 with prob $1 - p - q$ $R_1: 7p + 3q - 5(1 - p - q)$ $R_2: -2p - q + 4(1 - p - q)$ $\Rightarrow 12p + 8q = 5\frac{7}{13}$ A1 E1 7 CAO M1 any correct expression either equation correctly with coefficient of p and q correctly simplified		13			correct founding if 3st used
(ii) Value of game $= 4 \times \frac{5}{13} - 1 = \frac{7}{13}$ B1 1 AG or $\left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ must see correct calculation (b) Let Corrie play C_1 with prob p , C_2 with prob q , C_3 with prob $1 - p - q$ $R_1: 7p + 3q - 5(1 - p - q)$ $R_2: -2p - q + 4(1 - p - q)$ $\Rightarrow 12p + 8q = 5\frac{7}{13}$ A1 AG or $\left(4 - 9 \times \frac{5}{13}\right) = \frac{7}{13}$ any correct expression either equation correctly with coefficient of p and q correctly simplified			F.1	_	a.o
(b) Let Corrie play C_1 with prob p , C_2 with prob q , C_3 with prob $1-p-q$ $R_1: 7p+3q-5(1-p-q)$ $R_2: -2p-q+4(1-p-q)$ $\Rightarrow 12p+8q=5\frac{7}{13}$ A1 must see correct calculation must see correct calculation any correct expression either equation correctly with coefficient of p and q correctly simplified		$R_1 \frac{13}{13}$ of time and $R_2 \frac{13}{13}$ of time	EI	7	CAO
(b) Let Corrie play C_1 with prob p , C_2 with prob q , C_3 with prob $1-p-q$ $R_1: 7p+3q-5(1-p-q)$ $R_2: -2p-q+4(1-p-q)$ $\Rightarrow 12p+8q=5\frac{7}{13}$ A1 either equation correctly with coefficient of p and q correctly simplified	(ii)	Value of game = $4 \times \frac{5}{13} - 1 = \frac{7}{13}$	B1	1	AG or $\left(4-9\times\frac{5}{13}\right) = \frac{7}{13}$
prob q , C_3 with prob $1-p-q$ $R_1: 7p + 3q - 5(1-p-q)$ $R_2: -2p - q + 4(1-p-q)$ $\Rightarrow 12p + 8q = 5\frac{7}{13}$ A1 any correct expression either equation correctly with coefficient of p and q correctly simplified	<i>a</i> >				must see correct calculation
$R_1: 7p + 3q - 5(1 - p - q)$ $R_2: -2p - q + 4(1 - p - q)$ $\Rightarrow 12p + 8q = 5\frac{7}{13}$ A1 any correct expression either equation correctly with coefficie of p and q correctly simplified	(b)				
$R_2: -2p - q + 4(1 - p - q)$ $\Rightarrow 12p + 8q = 5\frac{7}{13}$ A1 either equation correctly with coefficient of p and q correctly simplified					
$\Rightarrow 12p + 8q = 5\frac{7}{13}$ A1 either equation correctly with coefficiency of p and q correctly simplified			M1		any correct expression
A1 of p and q correctly simplified		2 1 1 (1 1)			
or p and y correctly simplified		$\Rightarrow 12p + 8q = 5\frac{7}{13}$	A1		1 7
$6p + 5q = 3 \frac{6}{}$		$6p + 5q = 3 \frac{6}{13}$			or p and q correctly simplified
13		15	m1		may reason that $p(C_1) = 0$ from part(a)E1
$\Rightarrow q = \frac{9}{13}$ A1CS may reason that $p(C) = 0$ from part(a) with M1, A1, A1, E1 from 2 × 2 equation		$\Rightarrow q = \frac{9}{13}$			with M1, A1, A1, E1 from 2×2 equations
$\Rightarrow q = \frac{9}{13}$ $p = 0$ $m1$ A1CS O $may reason that p(C_1) = 0 from part(a) with M1, A1, A1, E1 from 2 \times 2 equation 3r - 5s = \frac{7}{13}$		p=0	О		$3r-5s=\frac{7}{2}$
		-			13
$-r + 4s = \frac{7}{13}$					$-r + 4s = \frac{7}{13}$
⇒ Optimal mixed strategy is		⇒ Optimal mixed strategy is			15
C_1 with prob 0		-			
C_2 with prob $\frac{9}{13}$ Condone 0.692		C_2 with prob $\frac{9}{12}$			Condone 0.692
C_3 with prob $\frac{4}{13}$ E1 5 CAO & 0.308		13	E1	5	CAO & 0.308
Total 13				13	

MD02 (cont)

MD02 (con	t)								
Q		Solution			Marks	Total			Comments
5(a)	PQSV has lor		ζ		B1		Both	of these	
	PQTV has lo	ngest journey	13)		D1		Dom	or these	
	Since 12 < 13	, <i>PQSV</i> is bet	ter		E1	2	OE		
(b)	Stage	State	Action		alculation	Val	110		
	Stage	State	SV	C	aicuiation	-			
	1	T	TV			9		D1	
		U	UV	-	_	12		} B1	
		U	UV			14			
	2	0	QS	M	ax (12, 11)	12	2	M1	2 values correct
		<u>y</u>	QT QT		[ax (12, 11)]	13		1111	2 values collect
			QU		lax(7, 12)	12		A 1	All correct with pairs of
			20	147	(7, 12)	12		711	correct values compared in calculation column
		R	RS	M	ax (10, 11)	11	1	M1	2 values correct
		K	RT		[ax (10, 11)]	14		1411	2 values correct
			RU		[ax (8, 12)]	12		A1	All correct with pairs of
			AC .	147	(0, 12)	12		711	correct values compared to calculation column
	3	P	PQ	M	[ax (9, 12)	12	2.	A1	CSO; all table correct
		1	PR		$\frac{(x, y, 12)}{(x, y, 11)}$	11		111	With word "MAX" seen at
									least once (or 12 > 11 etc)
	Using their m	inimum at eta	uga 3		M1		Impli	ied by ro	ute starting <i>PR</i>
	Come uich in	mmum at Sta	ige j		171 1		mipii		if that is their least value)
	Minimax rout	e from P to V	is <i>PRSV</i>		A1	8	SC I		rrect minimax route when
							sever	al values	in table are incorrect
				otal		10			
Ne	etwork approac	ch : Use same	mark schem	e for	6 marks ins	isting or	n precis	sely these	e values, pairs of correct

Network approach: Use same mark scheme for 6 marks insisting on precisely these values, pairs of correct values **seen** and considered with maximum selected for first two A marks, and word 'Max' seen and all correct for final A mark

MD02 (cont)				~
Q	Solution	Marks	Total	Comments
6(a)	Value of cut = $10 + 10 + 15 - 4 - 1$	M1		condone one slip if working shown
	= 30	A1	2	
(b)	BT 2, DE 3, ET 12	B1		any 2 correct
(~)	21 2, 22 0, 21 12	B1	2	all correct
(-)(*)	Initial flavor formand and hash an double		_	
(c)(i)	Initial flows forward and back or double	M1		Condone pairs of values, (coordinates)
	Arc with arrows(at least 6 pairs correct)	A 1	_	with single arrow
		A1	2	all correct (condone pairs with single
(40)		3.61		arrow provided key indicated)
(ii)	Path Flow	M1		first correct path and flow
	SABT 2	A1		another correct path and flow
	SCDET 1	A 1		all correct
	SACBT 1			(other possibilities also)
	(or SCBT instead of SACBT with flow 1			
	A		$\stackrel{\mathcal{Z}_0}{\longrightarrow}$	В
	•		 X 6	
			A 6	$//$ χ_{χ}
	2×5,			
	7910		v 4	0///0
	$X''' \qquad \underset{1}{\mathscr{A}} \uparrow \downarrow_{0}^{X}$, , ,	1/2 _V	0///0
	$S \bullet \longleftarrow \qquad \qquad \stackrel{1+}{\downarrow} 0$		//01	0
	\mathcal{Z}_1		X0,	D
		/ '		5
	87		\$6	$\chi \sqrt{\frac{3}{2}}$ $\sqrt{\frac{3}{2}}$
	C			$\frac{\chi_2}{\sqrt{2}}$
			5	
				E
	Must have forward and backward flows	M1		augmenting flows (6 pairs correct)
		A1	5	correct
(iii)				Alternative SA (3 & 9) SC (0&8)
	$\stackrel{A}{\longleftarrow}$		10	
	15			
	13/			5
	\sqrt{5}		4_/	<i>y</i> 1
	s•	/		
	3•			D/ 10 T
	13		13	
	13			13
	C			4
			9	
				E
	May have			
	SA(14), SC(14)			
	and $AC(4)$ using			
	alternative			
	Maximum flow values	M1		at least 8 correctly interpreted from their
	THE THE PARTY OF T	1,11		Figure 4 but 24 < their maxflow < 29
		A1	2	1 15010 7 001 27 \ 111011 111011 11011 \ \ \ \ \ \ \ \ \
			۷	
(d)	Cut through AB, CB, CD and CE	B1		But must have total flow of 28 in their
	May use $\{S,A,C\} / \{B,D,E,T\}$			network (condone one slip)
		B1	1	

Total	14	
TOTAL	75	