



# Mathematics (MEI)

Advanced GCE 4772

**Decision Mathematics 2** 

# Mark Scheme for June 2010

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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.

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1.

$(a)(i) \sim c \Rightarrow e$	B1	
(ii) $(c \Rightarrow \neg e) \Leftrightarrow (\neg c \Rightarrow e)$ 1 0 01 0 01 1 1 or 0 1 10 0 10 0 0	M1 A1 M1 A1	line of a TT both propositions 1 or both 0 an "⇒" correct all OK
(b)(i) Circuit is $\sim x \lor y$ . This is $x \Rightarrow y$ .	B1	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	B4	
(ii) $(\sim p \land \sim q) \Rightarrow r$	M1 A1	implication noted
(iii) $(\sim p \land \sim q) \Rightarrow r$ is equivalent to $\sim r \Rightarrow \sim (\sim p \land \sim q)$	B1	
But we have $\sim r$ , so we have $\sim (\sim p \land \sim q)$ .	B1	
~(~p $\land$ ~q) is equivalent to p $\lor$ q	B1	
But we have $\sim q$ , so therefore p.	B1	

## Mark Scheme

2.

(i)	Dis	stanc	es lo	nge	r										B1
(ii)				0-											
	1	2	3	4	5	6			1	2	3	4	5	6	
1	8	15	8	8	7	8		1	1	2	3	4	5	6	
2	15	8	6	2	6	8		2	1	2	3	4	5	6	not part of answer
3	8	6	8	3	8	8		3	1	2	3	4	5	6	not purt of unower
4	8	2	3	8	10	17		4	1	2	3	4	5	6	
5	7	6	8	10	8	8		5	1	2	3	4	5	6	
6	8	8	8	17	8	8		6	1	2	3	4	5	6	
	1	2	3	1	5	6			1	2	3	4	5	6	
1	1	15	3	4	3 7	8		1	1	2	3	4 4	5	6	
2	15	30	6	2	6	23		2	1	1	3	4	5	1	
3	<u> </u>	6	0 00	3	<u> </u>	25		3	1	2	3	4	5	6	not part of answer
4	<u> </u>	2	3	<i>w</i>	10	17		4	1	2	3	4	5	6	
5	7	6	00	10	14	8		5	1	2	3	4	1	6	
6	8	23	80	17	8	16		6	1	1	3	4	5	1	
		-	-		-			-		-					
		2	3	4	5	6		-	1	2	3	4	5	6	
	30	15	21	17	1	8		1	2	2	2	2	5	6	M1 30 in top left
2	15	30	0	2	6	23		2	1	1	3	4	2	1	A1 times
	17	2	12	3 1	12 8	29 17		3 1	2	2	2	4	2	2	A1 6 to 3 route = $1$
5	17	6	12	4	0	17		4	 1	2	2	2	$\frac{2}{2}$	6	A1 rest of route
6	8	23	29	17	8	16		6	1	1	1	4	5	1	in rest of route
		23	27	17	0	10		U	1	1	1		5	-	
	1	2	3	4	5	6			1	2	3	4	5	6	
1	30	15	21	17	7	8		1	2	2	2	2	5	6	not part of anguar
2	15	12	6	2	6	23		2	1	3	3	4	5	1	not part of answer
3	21	6	12	3	12	29		3	2	2	2	4	2	2	
4	1/	6	3 12	4	8 12	1/ 8		4	 1	2	3 2	2	2	6	
6	8	23	29	17	8	16		6	1	1	1	4	5	1	
		23	27	17	0	10		U	1	1	1		5	-	
	1	2	3	4	5	6			1	2	3	4	5	6	
1	30	15	20	17	7	8		1	2	2	2	2	5	6	
2	15	4	5	2	6	19		2	1	4	4	4	5	4	not part of answer
5	20	2	0	5	0	20		5	4	4	4	4	4	4	
4	1/	6	11	4	0	1/		+ 5	2 1	2	2 2	2	2	6	
6	8	19	20	17	8	16		6	1	4	4	4	5	1	
		1)		L * /	5										
	1	2	3	4	5	6			1	2	3	4	5	6	
	14	13	18	15	7	8		1	5	5	5	5	5	6	
$\frac{2}{2}$	13	4	5	2	6	14		2	5	4	4	4	5	5	not part of answer
3	18	2	0	5	0	19		<u> </u>	4	4	4	4	4	4	not pure or uno ver
4	13	6	3 11	4	0	10		4	2 1	2	2 2	2	2	<u>∠</u> 6	
6	8	14	19	16	8	16	-	6	1	5	5	5	5	1	
		1-7	17	10	0	10	L	v	1		5		5		
	1	2	3	4	5	6			1	2	3	4	5	6	
	14	13	18	15	7	8		1	5	5	5	5	5	6	und mont of
2	13	4	5	2	6	14		2	5	4	4	4	5	5	not part of answer
	18	2 2	0	5	0	19		5	4 2	4	4	4 2	4	4	
4	13	6	) 11	4	0	10	-	4	 1	2	2 2	2	2	6	
6	8	14	19	0	12	0		5	1	5	∠ 5	∠ 5	2 5	1	
	0	1-1	17	10	0	10	i	U	1	5	5	5	5	1	

(iii) cont	
It has found all shortest times and corresponding routes.	B1 B1
Shortest time from x to y is in x row and y column of time	
matrix.	
For route look in x row and y column of route matrix. This	B1
gives first vertex "en route". Repeat, looking in row	
corresponding to the current "en route" vertex and the y	
column, until the "en route" vertex is y.	
Shortest time from 3 to 6 is 19.	B1
Corresponding route is 3 to 4 to 2 to 5 to 6.	B1
(iv) On time matrix $-1(7)5(6)2(2)4(3)3(19)6(8)1$ so 45	B1
From route matrix – 1 5 2 4 3 4 2 5 6 1	B1
(v) Lower bound = $7 + 8 + 19 = 34$	M1
	A1 7+8
	A1 19
	-
(vi) $82 + 8 = 90$ minutes	B1



**Mark Scheme** 

June 2010



# Mark Scheme

· · ·	Max	1802	x + 90y	+ 110z	5					B1	
	st	2x +	-5v + 3	z < 30						B1	
	~ ~	4x +	y + 2	$z \le 24$						B1	
			-								
(ii)					1						
	Р	Х	у	Ζ	s1	s2		RHS			
	1	-180	-90	-110	0		0	0		M1	initial tableau
	0	2	5	3	1		0	30		A1	
	0	4	1	2	0		1	24			
	1	0	-45	-20	0	4	5	1080	_	M1	first iteration
	0	0	4.5	2	1	-0.	5	18		A1	
	1	1	0.25	0.5	10	0.2	5	12(0	-		
	1	0	0	<u> </u>	10	4	0	1260	-	M1	second iteration
		0	1	7/18	1/19	5/1	9	4		A1	
	0	1	0	//10	-1/10	5/1	0	5			
	T1 /	· · · ·	C1 ·	• 1	1 .	1				D1	D1
	Identi	incation	of basic	c variat	ples + y	values				BL	BI
			1 /	A 1	10					D1	
(iii)	Over	two wee	eks(x =	3 and 2	z = 18					DI	
(iii)	Over	two wee	eks(x =	3 and 2	z = 18					DI	
(iii) (iv)	Over Deger	two wee	eks (x = technica	3 and 2 al term	z = 18) not rec	luired	) – (	object	tive	B1 B1	same obj value
(iii) (iv)	Over Deger plane	two wee neracy ( s are par	eks (x = technica allel to	3 and 2 al term bounda	z = 18) not rec ary line	juired	) – (	object	tive	B1 B1 B1	same obj value line of solutions
(iii) (iv)	Over Degen planes	two wee neracy ( s are par	technicates $(x = x)$	3 and 2 al term bounda	not rec ary line	juired	) – (	object	tive	B1 B1 B1	same obj value line of solutions
(iii) (iv) (v)	Over Degen planes	two wee neracy ( s are par	eks (x = technica callel to	3 and 2 al term bounda	not rec ary line	juired	) – (	object	tive	B1 B1 B1	same obj value line of solutions
(iii) (iv) (v)	Over Degen planes	two ween two ween two ween neracy ( $rac{1}{2}$ s are particular p	eks (x = technica rallel to $y$	3 and 2 al term bounda	z = 18)not rec ary line s1 s2	juired	) – ( s4	object	tive RHS	B1 B1 B1	same obj value line of solutions
(iii) (iv) (v)	Over Degen planes	two wee neracy ( $rac{1}{5}$ s are par P = x 0 = 1	eks (x = technica rallel to $y$	3 and 2 al term bounda	not rec ary line $s1 s2 \\ 0 0$	uired	) - c s4 -1	bject a 0	tive RHS 7	B1 B1 B1 B1	same obj value line of solutions $= \rightarrow <+>$
(iii) (iv) (v)	Over Degen planes	two wee neracy ( s are par P = x 0 = 1 1 = -180	eks (x = technica rallel to y 1 -90	al term bounda	not rec ary line $\frac{s1}{0} \frac{s2}{0}$	uired 2. <u>s3</u> 0 0	)-c s4 -1 0	a 0 0	RHS 7 0	B1 B1 B1 B1 B1 B1	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$
(iii) (iv) (v)	Over Degen planes	two week neracy ( s are part $\frac{P}{0}$ x $\frac{1}{1}$ -180 0 2	eks (x = technica rallel to y 1 -90 5	$\frac{3}{2}$ and $\frac{1}{2}$ al term bounda $\frac{z}{0}$ -110 3	not rec ary line $\frac{s1}{0} \frac{s2}{0} $	s3 0 0 0	$) - c$ $\frac{s4}{-1}$ $0$ $0$	a 0 0	RHS           7           0           30	B1 B1 B1 B1 B1 B1 B1	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$
(iii) (iv) (v)	Over Degen planes	two week neracy ( $rac{1}{5}$ s are part P = x 0 = 1 1 = -180 0 = 2 0 = 4	eks (x = technica rallel to y 1 -90 5 1	3 and 2 al term bounda z 0 -110 3 2	z = 18) not rec ary line $\frac{s1  s2}{0  0}$ $\frac{0  0}{1  0}$ $0  1$	s3 0 0 0 0	) - 0 $\frac{s4}{-1}$ 0 0 0	a 0 0 0 0	RHS           7           0           30           24	B1 B1 B1 B1 B1 B1 B1 B1	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ pow objective
(iii) (iv) (v)	Over Degen planes	two weet neracy ( $rac{1}{5}$ s are part P = x 0 = 1 1 = -180 0 = 2 0 = 4 0 = 1	$\frac{y}{1}$	3 and z         al term         bounda         z         0         -110         3         2         0	z = 18) not rec ary line $s1  s2$ $0  0$ $1  0$ $0  1$ $0  0$	s3 0 0 0 0 1	) - 0 $\frac{s4}{-1}$ 0 0 0 0	a 0 0 0 0 0	RHS           7           0           30           24           7	B1 B1 B1 B1 B1 B1 B1 B1	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective
(iii) (iv) (v)	Over Degen planes	P       x         0       1         1       -180         0       2         0       4         0       1         0       1	$\frac{y}{1}$	3 and z         al term         bounda         z         0         -110         3         2         0         0         0         0         0         0	$ \begin{array}{c} \text{not rec}\\ \text{s1}  \text{s2}\\ \hline 0  0\\ \hline 0  0\\ \hline 0  1\\ \hline 0  0\\ \hline 0 $	s3 0 0 0 0 1 0	) - 0 $\frac{s4}{-1}$ 0 0 0 -1	a 0 0 0 0 0 1	RHS           7           0           30           24           7           7	B1 B1 B1 B1 B1 B1 B1 B1 B1	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective minimise A
(iii) (iv) (v)	Over Degen planes	two week neracy ( $rac{1}{5}$ s are part or $rac{1}{1}$ $rac{-180}{0}$ $rac{1}{2}$ or $rac{1}{2}$ $rac{1}{1}$ $rac{-180}{0}$ $rac{1}{2}$ $rac{1}{1}$ $rac{1}$ $rac{1}{1}$ $rac{1}$ $rac{1}$ $rac{1}{1}$	$\frac{y}{1}$ $\frac{y}{1}$ $\frac{y}{1}$ $\frac{1}{1}$ $\frac{y}{1}$ $\frac{1}{1}$ $\frac{1}{1}$	3 and 2       al term       bounda       z       0       -110       3       2       0       0       0	$\begin{array}{c} x = 18 \\ x = 1$	s3 0 0 0 0 1 0	) - 0 $\frac{s4}{-1}$ 0 0 0 -1	a 0 0 0 0 0 1	RHS           7           0           30           24           7           7	B1 B1 B1 B1 B1 B1 B1 B1 or	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective minimise A
(iii) (iv) (v)	Over Degen planes	two wee neracy ( s are par $\frac{P}{0} = \frac{x}{1}$ $\frac{1}{1} = -180$ $\frac{0}{0} = \frac{2}{1}$ $\frac{0}{0} = \frac{1}{1}$ $\frac{1}{0} = \frac{1}{1}$ $\frac{1}{0} = \frac{1}{1}$	eks (x = technica rallel to y 1 -90 5 1 1 1 1 1	al term boundation z 0 -110 3 2 0 0 z	$ \begin{array}{c} \text{not rec}\\ \text{ary line}\\ \hline s1 & s2\\ \hline 0 & 0\\ \hline 0 & 0\\ \hline 1 & 0\\ \hline 0 & 0\\ \hline 0 & 0\\ \hline s1 & s2\\ \hline \end{array} $	s3 0 0 0 0 1 0 1 0 83	) - 0 $\frac{s4}{-1}$ 0 0 0 -1 s4	a 0 0 0 0 1 1	RHS           7           0           30           24           7           7           7           7           7           7           7           7           7	B1 B1 B1 B1 B1 B1 B1 B1 or	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective minimise A
(iii) (iv) (v)	Over Degen planes	two wee         neracy (         s are par $P$ x         0         1         -180         0         2         0         4         0         1         -180	eks (x = technica vallel to y -90 5 1 1 1 1 1 y -M-90	3 and z         al term         bounda         z         0         -110         3         2         0         0         2         0         2         0         2         0         10	$ \begin{array}{c} \text{not rec}\\ \text{ary line}\\ \hline s1 & s2\\ \hline 0 & 0\\ \hline 0 & 0\\ \hline 1 & 0\\ \hline 0 & 1\\ \hline 0 & 0\\ \hline s1 & s2\\ \hline 0 & 0\\ \hline \end{array} $	s3 0 0 0 0 1 0 83	) - 0 $\frac{s4}{-1}$ 0 0 0 -1 $\frac{s4}{M}$	a 0 0 0 0 1 1	RHS           7           0           30           24           7           7           8           7	B1 B1 B1 B1 B1 B1 B1 or B1	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective minimise A $= \rightarrow \leq + \geq$
(iii) (iv) (v)	Over Degen planes	two wee neracy ( s are par $\frac{P}{x}$ $\frac{x}{0}$ $\frac{P}{1}$ $\frac{x}{0}$ $\frac{1}{1}$ $\frac{x}{1}$ $\frac{x}{-M-180}$ $\frac{x}{2}$	$\frac{y}{1}$ $\frac{y}{1}$ $\frac{1}{-90}$ $\frac{5}{1}$ $\frac{1}{1}$ $\frac{y}{-M-90}$ $5$	al term boundar z 0 -110 3 2 0 0 0 z -110 3	z = 18) not rec ary line s1  s2 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0	s3 0 0 0 0 1 0 53 0 0	) - 0 $\frac{s4}{-1}$ 0 0 0 -1 $\frac{s4}{M}$ 0	a 0 0 0 0 1 1 a 0 0	RHS           7           0           30           24           7           7           7           8           -7M           30	B1 B1 B1 B1 B1 B1 B1 B1 or B1 B1	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective minimise A $= \rightarrow \leq + \geq$ $\leq row$
(iii) (iv) (v)	Over           Degen           planes           A           1           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0	two week neracy ( $rac{1}{5}$ are part or $rac{1}{5}$ are part or $rac{1}{5}$ are part or $rac{1}{5}$ or $rac{1}{5}$ or $rac{1}{5}$ or $rac{1$	$\frac{y}{1}$ $\frac{y}{1}$ $\frac{1}{-90}$ $\frac{5}{1}$ $\frac{1}{1}$ $\frac{y}{-M-90}$ $\frac{5}{1}$	$\begin{array}{c c} 3 \text{ and } z \\ \hline 0 \\ -110 \\ \hline 3 \\ \hline 2 \\ \hline 0 \\ \hline 0 \\ \hline \\ -110 \\ \hline 3 \\ \hline 2 \\ \hline 0 \\ \hline 0 \\ \hline \\ 2 \\ \hline 2 \\ \hline \\ 2 \\ \hline $	$ \begin{array}{c} \text{not rec}\\ \text{ary line}\\ \hline s1 & s2\\ \hline 0 & 0\\ \hline 0 & 0\\ \hline 1 & 0\\ \hline 0 & 0\\ \hline s1 & s2\\ \hline 0 & 0\\ \hline 1 & 0\\ \hline 0 & 1\\ \hline 0 & 0\\ \hline 1 & 0\\ \hline 0 & 1\\ \hline 0 & 1\\ \hline 0 & 1\\ \hline 0 & 1\\ \hline 0 & 0\\ \hline 1 & 0\\ \hline 0 & 1\\ \hline 0 & 0\\ \hline 0 & 1\\ \hline $	s3 0 0 0 0 1 0 53 53 0 0 0	) - 0 $\frac{s4}{-1}$ 0 0 0 -1 $\frac{s4}{M}$ 0 0	a 0 0 0 0 1 1 a 0 0 0 0 0 0 0	RHS         7         0         30         24         7         7         7         7         7         30         24         7         0         30         24	B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective minimise A $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$
(iii) (iv) (v)	Over           Degen           planes           A           1           0	P       x         0       1         1       -180         0       2         0       4         0       1         -M-180       2         4       1	$\frac{y}{1}$ $\frac{y}{1}$ $\frac{1}{-90}$ $\frac{5}{1}$ $\frac{1}{1}$ $\frac{y}{-M-90}$ $\frac{5}{1}$ $\frac{1}{1}$ $\frac{1}{1}$	$   \begin{array}{c}     3 \text{ and } z \\     \hline     10 \\     \hline     2 \\     0 \\     \hline     2 \\     0 \\     \hline     0 \\     \hline     2 \\     0 \\     \hline     0 \\     \hline     0 \\     \hline     2 \\     0 \\     \hline     0 \\     \hline     0 \\     \hline     0 \\     \hline     2 \\     0 \\     \hline     0 \\     0 \\     \hline     0 \\     0 \\     0 \\     0 \\     \hline     0 \\   $	z = 18) not rec ary line $\frac{s1}{0} \frac{s2}{0} \frac{0}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{1}{0} \frac{1}{0} \frac{1}{0} \frac{0}{0} \frac{1}{0} \frac{1}{0} \frac{0}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{0}{0$	s3 0 0 0 0 1 0 1 0 53 0 0 0 1	) - 0 $\frac{s4}{-1}$ 0 0 0 -1 $\frac{s4}{M}$ 0 0 0	a 0 0 0 0 1 1 a 0 0 0 0 0 0 0 0 0 0 0 0	RHS         7         0         30         24         7         7         8         7         7         30         24         7         7         7         7         7         7         7         7         7         7         24         7         30         24         7	B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective minimise A $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective
(iii) (iv) (v)	Over           Deget           planes           A           1           0	P       x         0       1         1       -180         0       2         0       4         0       1         0       2         0       4         0       1         2       4         1       1         1       1	$\frac{y}{1}$ $\frac{y}{-90}$ $\frac{y}{5}$ $\frac{1}{1}$ $\frac{y}{-M-90}$ $\frac{5}{1}$ $\frac{1}{1}$ $\frac{1}{1}$ $\frac{1}{1}$	$   \begin{array}{c c}     3 \text{ and } z \\     \hline     al \text{ term bounda} \\     \hline      \hline      \hline           $	z = 18) not rec ary line $\frac{s1}{0} \frac{s2}{0} \frac{0}{0} \frac{0}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{0}{0} \frac{0}{0} \frac{1}{0} \frac{0}{0} \frac{0}{0$	s3 0 0 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0	) - 0 $\frac{s4}{-1}$ 0 0 0 -1 $\frac{s4}{-1}$ M 0 0 0 -1	a 0 0 0 0 0 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0	RHS         7         0         30         24         7         7         7         7         7         7         7         7         7         7         7         7         7         30         24         7         7         7         7         7         7	B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B1 B	same obj value line of solutions $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective minimise A $= \rightarrow \leq + \geq$ $\leq row$ $\geq row$ new objective maximice P

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