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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Mathematics 6360

MDO2 Decision 02

Mark Scheme

2008 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.

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
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**.

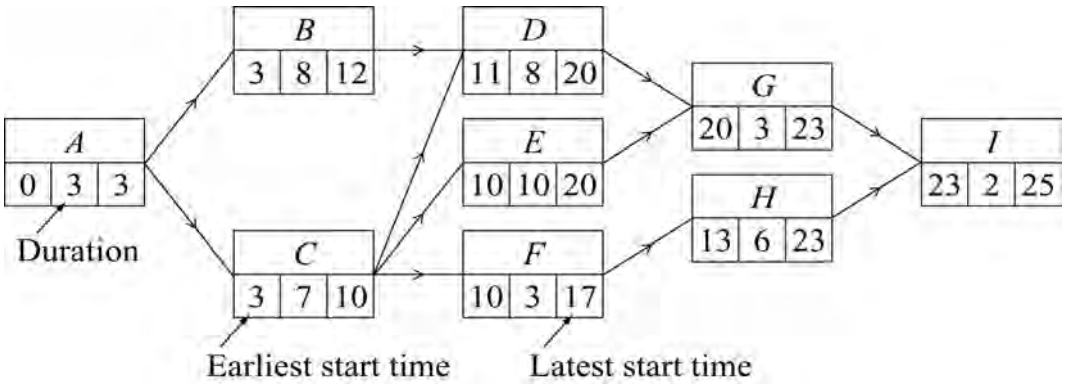
Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

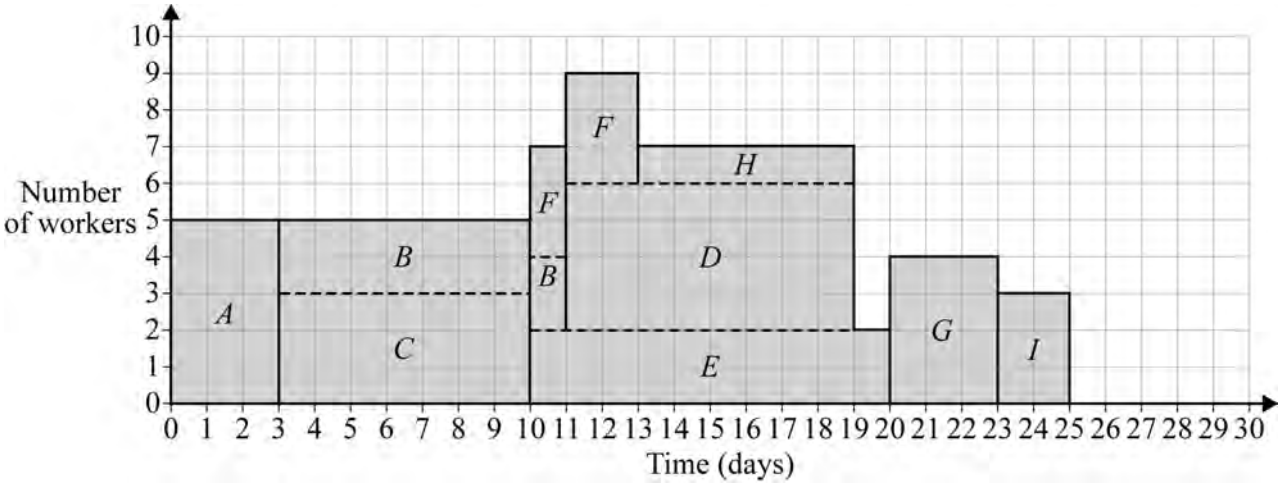
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

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

MD02

Q	Solution	Marks	Total	Comments
1(a)	*G*, *H* and *I* in correct place	M1		
	Lines (with arrows) correct	A1	2	
(b)	Forward pass (no more than 1 error FT)	M1		See below
	Early start times correct	A1		
	Backward pass (no more than 1 error FT)	M1		
	Latest finish times correct	A1	4	
(c)	Correct critical path: *ACEGI*	B1		
	Correct minimum time: 25 days	B1	2	
(d)	"Their" critical activities	B1√		See below
	Block $0 \le t \le 10$	B1		
	$10 \le t \le 11$	B1		
	All correct including labels	B1	4	CSO
(e)	Problem with *F* or day 11	M1		
	Delay start of *D* (by 2 days), then *G* and *I* (by 1 day)	A1		
	Extra time 1 day	B1	3	
	Total		**15**	





MD02 (cont)

Q	Solution	Marks	Total	Comments
2(a)				
		B1	1	Extra row of equal non-zero values (expect 15, 15, …)
(b)				
		M1		Attempt to reduce columns
		A1		Correct
				Final row may be different
		A1		Reduce rows correct
		B1		Zeros can be covered with 4 lines (shown)
		M1		Adjustment reducing uncovered elements by 1 and increasing double uncovered by 1
		A1		Correct
	Matching E3, B4, C2, D1	B1		
	Total time 44 min	B1	8	
(c)	No, time cannot be improved ** became 0 from 2nd tableau onwards B must take task 4 ⇒ D must …	B1 E1	2	Or other correct reasoning
	Total		**11**	

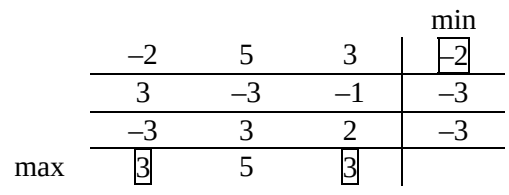
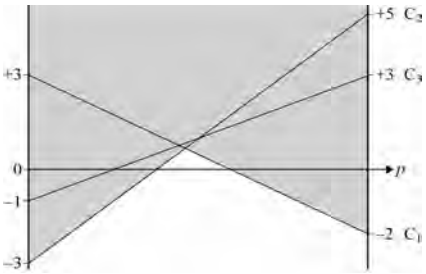
	Ash	Bob	Col	Dan	Emma
Task 1	14	10	12	12	14
Task 2	11	13	10	12	12
Task 3	13	11	12	**	12
Task 4	13	10	12	13	15
	15	15	15	15	15

	Ash	Bob	Col	Dan	Emma
Task 1	3	0	2	0	2
Task 2	0	3	0	0	0
Task 3	2	1	2	**	0
Task 4	2	0	2	1	3
	4	5	5	3	3

	Ash	Bob	Col	Dan	Emma
Task 1	3	0	2	0	2
Task 2	0	3	0	0	0
Task 3	2	1	2	**	0
Task 4	2	0	2	1	3
	1	2	2	0	0

	Ash	Bob	Col	Dan	Emma
Task 1	2	0	1	0	2
Task 2	0	4	0	1	1
Task 3	1	1	1	**	0
Task 4	1	0	1	1	3
	0	2	1	0	0

MD02 (cont)

Q	Solution	Marks	Total	Comments
3(a)	Rob's gain = Con's loss (at each entry of matrix)	E1	1	Zero-sum explained Rob's winnings + Con's winnings = 0 (for every pair of strategies)
(b)	 	B1 M1		min of rows and max of columns All values correct (seen) maximin = -2 minimax = 3 either correct
	$-2 \neq 3$ $\Rightarrow$ no stable solution	E1	3	
(c)	R_3 dominated by R_1 $(-3, 3, 2) < (-2, 5, 3)$ so never play R_3	E1	1	
(d)(i)	Choose R_1 with probability p and R_2 with probability $1 - p$			
	Expected gain when C plays: $C_1: -2p + 3(1-p) = 3 - 5p$ $C_2: \ 5p - 3(1-p) = 8p - 3$ $C_3: \ 3p - (1-p) = -1 + 4p$	M1 A1		Attempt at one expression All correct unsimplified
	 	M1 A1		Plotting expected gain for $0 \leq p \leq 1$ Correct with values at $p = 0$ and $p = 1$ clear
	$3 - 5p = 8p - 3$ $\Rightarrow p = \frac{6}{13}$	M1 A1		Choosing C_1 and C_2 intersection or their highest point
	Play R_1 with probability $\frac{6}{13}$ and R_2 with probability $\frac{7}{13}$	E1√	7	FT their p (statement needed)
(ii)	Value of game $= 3 - \frac{30}{13}$ $= \frac{9}{13}$	B1	1	Or $\frac{48}{13} - 3$ $= \frac{9}{13}$
	Total		**13**	

MD02 (cont)

Q	Solution	Marks	Total	Comments
4(a)	$x + z \le 9$ $2x + y + 4z \le 40$ $4x + 2y + 3z \le 33$	M1 A1	 2	One correct inequality or all using < All correct
(b)(i)	Pivot is **1** in z-column	M1		May be implied by use
	P | x | y | z | s | t | u | value 1 | 3 | –3 | 0 | 5 | 0 | 0 | 45 0 | 1 | 0 | **1** | 1 | 0 | 0 | 9 0 | –2 | 1 | 0 | –4 | 1 | 0 | 4 0 | 1 | 2 | 0 | –3 | 0 | 1 | 6	A1 A1 A1	 4	One row correct (other than pivot) Another row correct (other than pivot) All correct
(ii)	(Know optimal value **not** reached) since –3 in <u>top row</u>	 E1	 1	
(c)(i)	1 | $4\frac{1}{2}$ | 0 | 0 | $\frac{1}{2}$ | 0 | $\frac{3}{2}$ | 54 0 | 1 | 0 | 1 | 1 | 0 | 0 | 9 0 | $-2\frac{1}{2}$ | 0 | 0 | $-2\frac{1}{2}$ | 1 | $-\frac{1}{2}$ | 1 0 | $\frac{1}{2}$ | **1** | 0 | $-\frac{3}{2}$ | 0 | $\frac{1}{2}$ | 3	M1 A1 A1 A1	 4	Next pivot **2** in y-column and perhaps divide by 2 One row correct (other than pivot) Another row correct All correct
(ii)	Optimum value of P now reached $P = 54,\ x = 0,\ y = 3,\ z = 9$ $s = 0,\ \ t = 1,\ u = 0$	E1√ B1√ B1	 3	FT statement if their tableau has negative values in top row All correct and final tableau correct
	Total		**14**	

MD02 (cont)

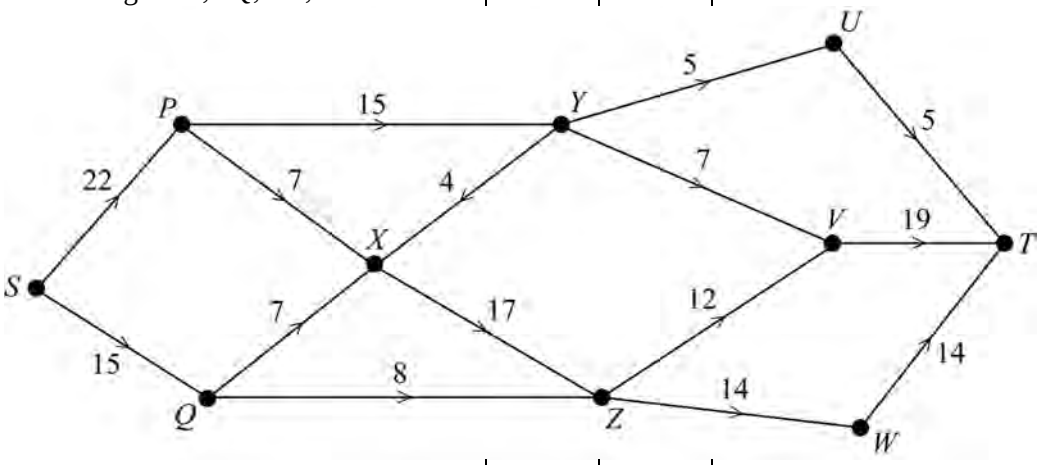
Q	Solution	Marks	Total	Comments
5(a)	Stage / State / From / Value			
	1, *H*, *T*, 5 *			
	I, *T*, 6 *			
	2, *F*, *H*, –2 + 5 = 3 *	B1		Stage 2 values correct
	T, 4			
	I, –2 + 6 = 4			
	G, *I*, 5 + 6 = 11 *			
	3, *C*, *H*, 4 + 5 = 9	M1		Stage 3 (6 values)
	F, 5 + 3 = 8 *			M0 for complete enumeration
	G, 2 + 11 = 13			
	D, *G*, –1+11 = 10*			
	E, *F*, 5 + 3 = 8 *	A1		Correct
	G, 3 +11 = 14			
	4, *A*, *C*, 2 + 8 = 10	M1		Stage 4 (4 values) and using minimum values from previous stage
	D, –1+10 = 9 *			
	B, *D*, –2 +10 = 8	A1		Stage 4 correct
	E, –3 + 8 = 5 *			
	5, *S*, *A*, 1 + 9 = 10 *			
	B, 5 + 5 = 10 *	A1	6	Stage 5 correct CSO
(b)	Minimum cost 10	B1		
	Routes *SBEFHT*	B1		First route correct
	SADGIT	B1	3	Second correct (no others)
	Total		**9**	

Solution table for 5(a):

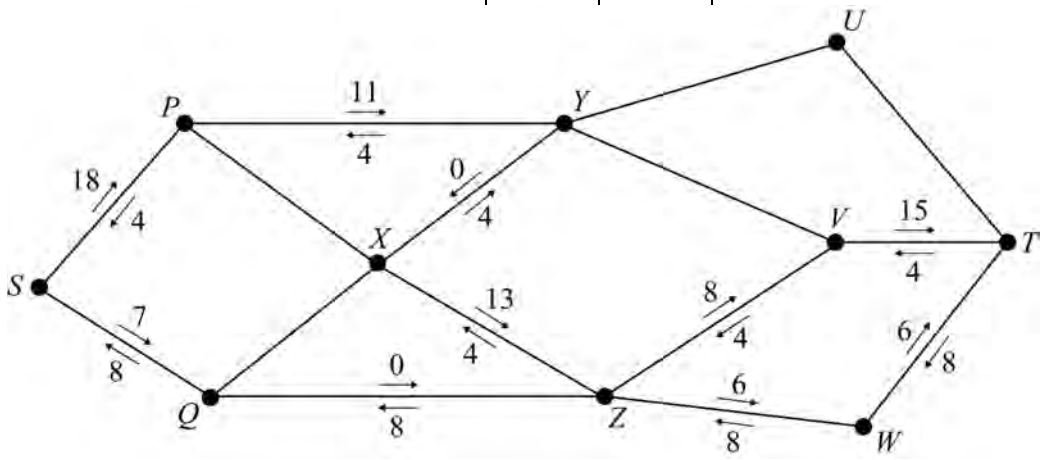
Stage	State	From	Value
1	*H*	*T*	5 *
	I	*T*	6 *
2	*F*	*H*	–2 + 5 = 3 *
		T	4
		I	–2 + 6 = 4
	G	*I*	5 + 6 = 11 *
3	*C*	*H*	4 + 5 = 9
		F	5 + 3 = 8 *
		G	2 + 11 = 13
	D	*G*	–1+11 = 10*
	E	*F*	5 + 3 = 8 *
		G	3 +11 = 14
4	*A*	*C*	2 + 8 = 10
		D	–1+10 = 9 *
	B	*D*	–2 +10 = 8
		E	–3 + 8 = 5 *
5	*S*	*A*	1 + 9 = 10 *
		B	5 + 5 = 10 *

MD02 (cont)

Q	Solution	Marks	Total	Comments
6(a)	Correct position of *S* and *T* Values on edges *SP*, *SQ*, *UT*, *VT* and *WT*	M1 A1	2	



(b)(i)	Cut *C* has value 40	B1	1	15 + 0 + 17 + 8
(ii)	Max flow ≤ 40	E1	1	
(c)	**Route** / **Flow** *SQZWT* / 8 *SPYXZVT* / 4 ( ) / ( ) ( ) / ( ) ( ) / ( )	B1 B1	2	
(d)(i)	3 forward and backward flows correct All initial values correct on edges below	M1 A1	2	



MD02 (cont)

Q	Solution	Marks	Total	Comments
6(d)(ii)				(Many different possibilities)
		M1		2 or more correct flows in table
		A1		Table correct (adding to 37)
		M1		At least 2 flows augmented on diagram
		A1	4	Correct forward and backward final flows
				Other possibility for ZV, VT, ZW and WT
(e)	Flow from *Y* to *X* is 3	B1	1	
	Total		**13**	
	TOTAL		**75**	

Route	Flow
SQZWT	8
SPYXZVT	4
SPYUT	5
SPYVT	6
SPXZVT	7
SQXZWT	6
SQXYVT	1