A-LEVEL
MATHEMATICS

Decision 2 – MD02
Mark scheme

6360
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Version/Stage Final V1.0

Mark schemes are prepared by the Lead Assessment Writer 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 associates 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 associate understands and applies it in the same correct way. As preparation for standardisation each associate 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, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

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.

Further copies of this Mark Scheme are available from aqa.org.uk

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

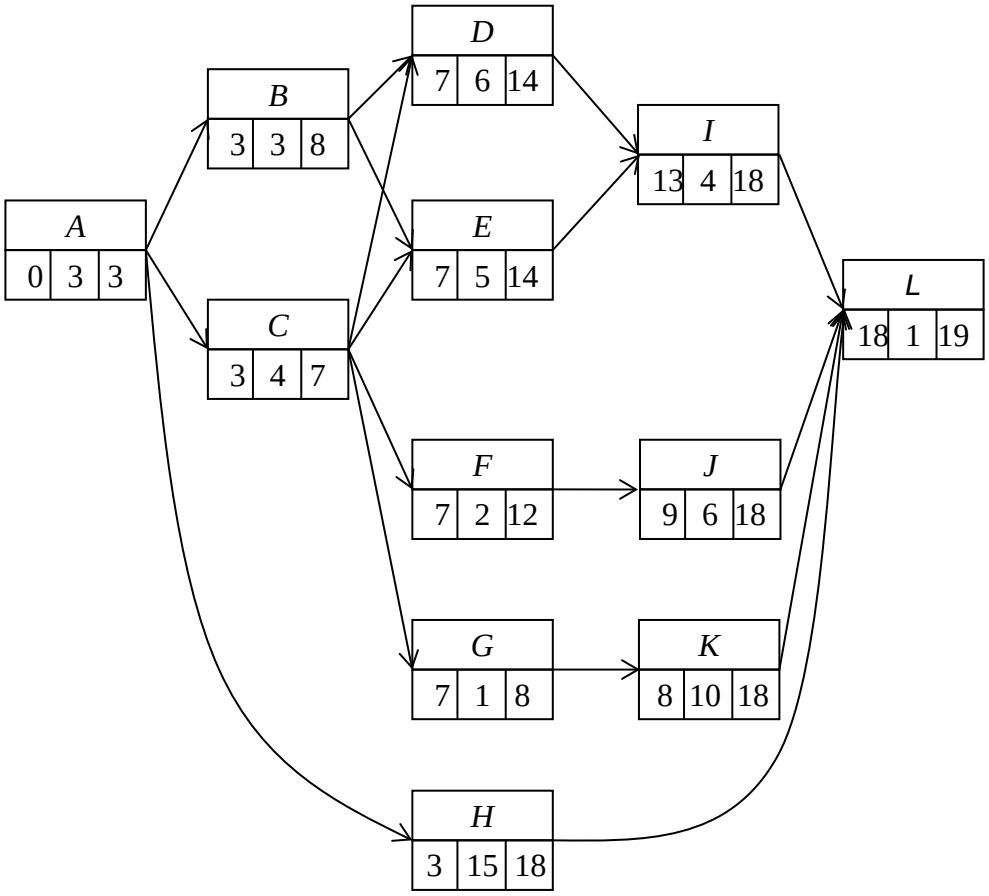
Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

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**.

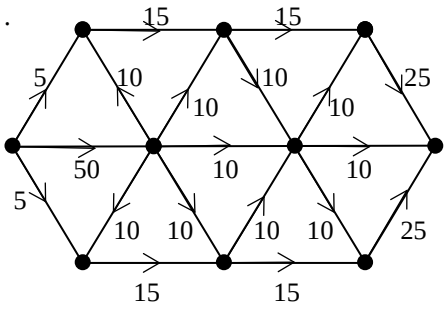
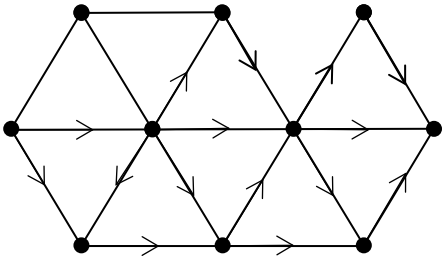
Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

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	Mark	Total	Comment
1(a)				
(a)		M1 A2	3	Network diagram -1 each independent error (ignore extra 'end' box)
(b)		M1 A1	2	Forward pass, correct at *D*, *E*, *F*
(c)		M1 A1	2	Backward pass, correct at 3 of *D*, *E*, *F*, *G* ft
(d)	*A*,*C*,*G*,*K*,*L* *(A)*,*H*,*(L)*	B1 B1	2	−1 for each extra
	Total		**9**	

Q	Solution	Mark	Total	Comment
2(a)	Row min –4, 0, –5	**M1**		Attempt to find maximin and minimax
	Max (row min) = 0			
	Col max 5, 3, 0, 1			Accept '*F* dominates *G*', col max 5, 3, 0
	Min (col max) = 0	**A1**		All rowmin and colmax values correct and maximin and minimax identified
	Max (row min) = Min (col max) = 0	**E1**		Full statement involving maximin and minimax and both values = 0
	Hence game has a stable solution.			If using dominance: Reduction to 2x2 M1 Reduction to 1x1 A1 Final statement E1
	Alex plays *B* Roberto plays *F*	**B1**	**4**	
(b)	Saddle point (*B*, *F*) ONLY	**B1**	**1**	
	Total		**5**	

Q	Solution	Mark	Total	Comment
3(a)	$C_1 = 60$	**B1**		
	$C_2 = 80$	**B1**	**2**	
(b)	e.g. .  	**M1** **A1**	**2**	Correct at *D*
(c)(i)		**M1**		Correct to *D*, *E*, *F* either by inspection or flow augmentation
		A1		All correct
	oe			
	MAX = 45	**B1**	**3**	
(ii)	CUT THRU' *EG*,*DG*, *DF*, *DC*, *AC*	**B1**		Or {*A*,*B*,*D*,*E*} {*C*,*FG*,,*H*,*IJ*}
	Max flow = Min cut	**E1**	**2**	Must have scored B1,B1 in point (C)
	Total		**9**	

Q	Solution	Mark	Total	Comment
4(a)				
		B1		1st and 2nd row correct
		B1	**2**	1st and 3rd row correct
(b)				
		B1		Correct pivot '*y*, 3' chosen and 11/3, 21/4 seen
		M1		Row operations
		A1	**3**	All correct
(c)				
		B1		Correct pivot '*x*, 5' chosen and 19/5, 11 seen
		M1		Row operations
		A1	**3**	All correct
(d)	$P = 25.8$ $z = r = t = 0$ $x = 3.8, y = 2.4$	**B1** **B1** **B1**	**3**	
	Total		**11**	

P	***x***	***y***	***z***	***r***	***t***	
1	–3	–6	–2	0	0	0
0	1	3	2	1	0	11
0	3	4	2	0	1	21

P	***x***	***y***	***z***	***r***	***t***	
1	–1	0	2	2	0	22
0	1	3*	2	1	0	11
0	5	0	–2	–4	3	19

Or

P	***x***	***y***	***z***	***r***	***t***	
1	–1	0	2	2	0	22
0	$\frac{1}{3}$	1	$\frac{2}{3}$	$\frac{1}{3}$	0	$\frac{11}{3}$
0	$\frac{5}{3}$	0	$-\frac{2}{3}$	$-\frac{4}{3}$	1	$\frac{19}{3}$

P	***x***	***y***	***z***	***r***	***t***	
5	0	0	8	6	3	129
0	0	15	12	9	–3	36
0	5*	0	-2	–4	3	19

Oe

P	***x***	***y***	***z***	***r***	***t***	
1	0	0	$\frac{8}{5}$	$\frac{6}{5}$	$\frac{3}{5}$	$\frac{129}{5}$
0	0	1	$\frac{4}{5}$	$\frac{3}{5}$	$-\frac{1}{5}$	$\frac{12}{5}$
0	1	0	$-\frac{2}{5}$	$-\frac{4}{5}$	$\frac{3}{5}$	$\frac{19}{5}$

Q	Solution	Mark	Total	Comment
5(a)	*A* dominates *B*	**E1**	**1**	
(b)	Reduced matrix			
	<table><tr><td></td><td>p</td><td>q</td><td>$1–p–q$</td></tr><tr><td>A</td><td>4</td><td>1</td><td>–1</td></tr><tr><td>C</td><td>–2</td><td>0</td><td>3</td></tr></table>	**E1**		Use of '$1–p–q$'
	Mark plays *A*, Owen loses $4p + q + –1(1–p–q)$	**M1**		One correct expression or reverse
	Mark plays *C*, Owen loses $–2p + 3(1–p–q)$	**A1**		Both correct or reverse
	$5p + 2q = 1.6$	**m1**		Correct use of 0.6 (or -0.6) Condone simplified equations
	$–5p – 3q = –2.4$	**A1**		2 correct equations
	$q = 0.8$ $p = 0$ $1–p–q = 0.2$	**A1**		At least 2 correct
	Owen plays *D* with prob 0 Owen plays *E* with prob 0.8 Owen plays *F* with prob 0.2	**B1**	**7**	All correct in context of *D*, *E*, *F*
	Total		**8**	

Q	Solution	Mark	Total	Comment
6(a)	Stage 2	**B1**		4 correct values
		M1		Choosing 2 'mins' out of 4 expressions
	Stage 3	**m1**		4 expressions
		A1		*EG* chosen
	Stage 4	**m1**		4 expressions, 1 in terms of x
	Stage 5	**B1**		Final value 48, indicated or stated
		A1	**7**	All correct (complete table)
(b)	$x + 41 = 48$	**M1**		Their $(x + 8 + k)$ = their (min)
	$x = 7$	**A1**	**2**	
(c)	*A B D G I K* *A B E G I K* *A C F H I K*	**B1** **B1** **B1**	**3**	Condone reverse (x3)
	Total		**12**	

Stage	State	From	Calculation	Value
1	*I*	*K*	12	12
	J	*K*	14	14
2	*G*	*I*	15 + 12	27
		J	14 + 14	(28)
	H	*I*	12 + 13	25
		J	14 + 12	(26)
3	*D*	*G*	$27 + x + 2$	$29 + x$
	E	*G*	27 + 9	36
		H	25 + 12	(37)
	F	*H*	25 + 13	38
4	*B*	*D*	$29 + x + 4$	$33 + x$
		E	36 + 4	40
	C	*E*	36 + 9	(45)
		F	38 + 6	44
5	*A*	*B*	$33 + x + 8$	$41 + x$
		B	40 + 8	48
	A	*C*	44 + 4	48

Q	Solution	Mark	Total	Comment
7(a)	Row minima: $(x + 4), (x + 2), (x + 5)$	**M1** **A1**	**2**	1 correct All 3 correct
(b)	4 | 0 | 2 | 5 3 | 1 | 2 | 0 3 | 2 | 0 | $x - 3$ 2 | $x - 4$ | $11 - x$ | 0	**M1** **A1** **A1**		Using correct/'their' row minima 3 rows correct All correct
	Reduce cols to give 2 | 0 | 2 | 5 1 | 1 | 2 | 0 1 | 2 | 0 | $x - 3$ 0 | $x - 4$ | $11 - x$ | 0	**M1** **A1**		3 rows correct All correct
	4 lines needed to cover 0's	**E1**		oe
	Match *AZ*, *BW*, *CY*, *DX* stated	**B1**	**7**	
(c)	$4x+14= 42$	**M1**		Their expression = 42
	$x = 7$	**A1**	**2**	
	Total		**11**	

Q	Solution	Mark	Total	Comment
8(a)	$x = 4$ $y = 17$ $z = 17$	**B1** **B1**	**2**	Any 2 correct All 3 correct
(b)	*B D G I K*	**B1**	**1**	
c(i)	Reduce *G* to 5 (as critical) oe	**E1**		Decrease *G* by 3
	Reduce *F* to 4 or 5 Reduce *F* to5	**E1** **E1**		Decrease *F* by 2 or 3 Decrease *F* by 2 Condone new values shown on diagram
	Don't reduce *E* (as path through E still not critical)	**E1**		
(ii)	25 (weeks)	**B1**		
(iii)	Cost (3 x 6 + 2 x 7) PI by 32 = £32 000	**M1** **A1**	**7**	
	Total		**10**	
	TOTAL		**75**	