Version 1.0: 0110

General Certificate of Education

Mathematics 6360

MD02 Decision 2

Mark Scheme

2010 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.

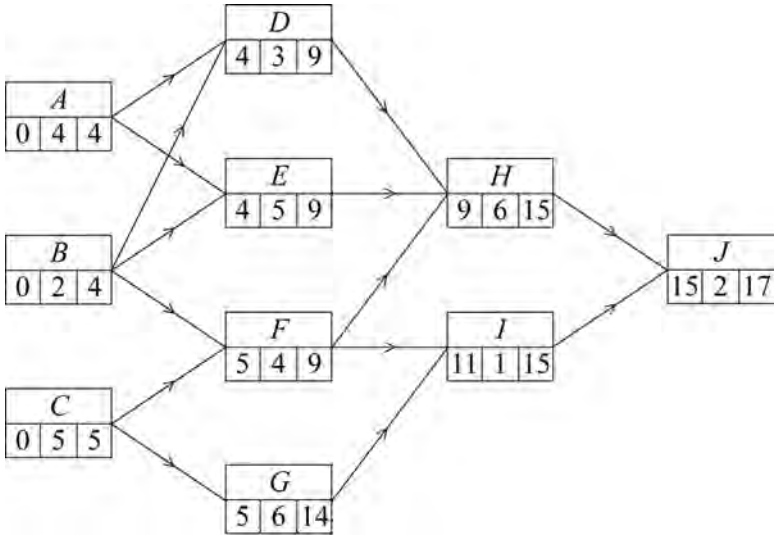
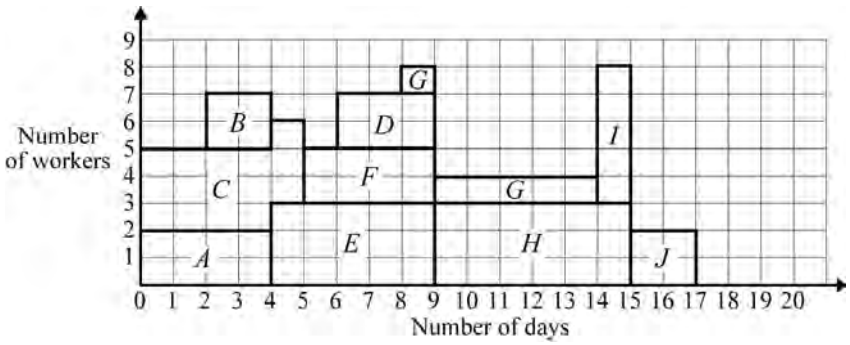
Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **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.

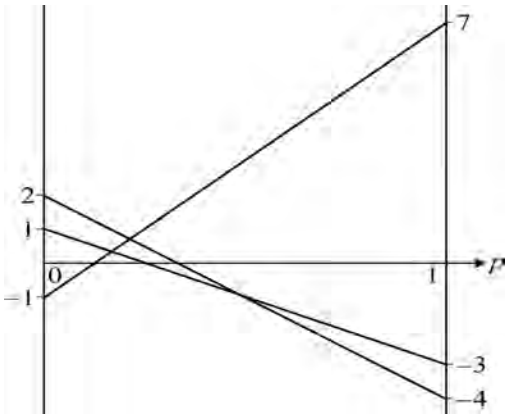
MD02

Q	Solution	Marks	Total	Comments
1				
(a)(i)	Earliest start times	M1 A1	 2	At least 4 correct (other than zeros) All correct
(ii)	Latest finish times	M1 A1	 2	Up to one error + follow through All correct
(b)	Float for G = 3 days	B1√	1	ft their G values
(c)	Critical paths $A\ E\ H\ J$ and $C\ F\ H\ J$ Minimum completion time = 17 days	B1 B1 B1	 3	First correct path Second path (and no others) Must be stated explicitly
(d)				
	One of their CPs – correct heights $A\ E\ H\ J$ and $C\ F\ (H\ J)$ correct	M1 A1		**NB** "holes" penalise first A1 earned
	B starting at 2 (and ending at 4) D starting at 6 (and ending at 9) G starting at 8 (and ending at 14) I starting at 14 (and ending at 15)	M1 A1 A1	 5	One correct with correct height Two correct with correct height All correct with correct height and no slack Withhold first A1 earned if it is not clear which activities take place at any given time
	Total		**13**	

MD02 (cont)

Q	Solution	Marks	Total	Comments
2(a)	8 7 9 10 8 9 x 8 7 11 12 10 9 9 10 11 9 8 11 11 12 12 12 12 12	B1	1	Adding extra row equal values
(b)(i)	0 0 1 3 0 1 $x-7$ 0 0 3 4 3 1 2 2 3 2 0 4 3 4 5 4 5 4	B1√		Reducing columns first
	0 0 1 3 0 1 $x-7$ 0 0 3 3 2 0 1 1 3 2 0 4 3 0 1 0 1 0	B1√		Reducing rows
	Zeros covered with 4 lines (stated or drawn) **0 0 1 3 0** **1 $x-7$ 0 0 3** 3 2 **0** 1 1 3 2 **0** 4 3 **0 1 0 1 0**	E1		or **0 0** 1 **3 0** 1 x-7 **0 0** 3 3 2 **0** 1 1 3 2 **0** 4 3 **0 1 0 1 0**
		M1		Augmentation – adding 1 to double covered and subtracting 1 from uncovered
	⇒ 0 0 2 3 0 1 $x-7$ 1 0 3 2 1 0 0 0 2 1 0 3 2 0 1 1 1 0	A1	5	or 0 0 2 4 0 0 $x-8$ 0 0 2 2 1 0 1 0 2 1 0 4 2 0 1 1 2 0
(ii)	S1, V2, Z3, T4	M1		At least 2 matched correctly or "rings" on final tableau
		A1	2	(Ron not assigned)
(iii)	Total time 32 (minutes)	B1	1	
(c)	V3, T4, R1	B1		First matching
	or V3, T4, Z1	B1	2	Second matching and no other
	Total		**11**	

MD02 (cont)

Q	Solution	Marks	Total	Comments
3(a)	Row min – 2 – 3 –5 Col max 4 0 –2	B1		Row minima and column maxima (all values)
	Max (row min) = – 2 Min (col max) = – 2	M1		Both attempted or stated/indicated
	Since these are equal, there is a stable solution	A1		Must have both values = – 2 plus statement (withhold if max (min) and min (max) not stated)
	Ann plays A_1 and Bill plays B_3 for play-safe	E1	4	
(b)(i)	Let Russ play R_1 with probability p			And R_2 with probability $1-p$
	C_1: expected gain $-4p + 2(1-p)$			$(2-6p)$
	$C_2 : 7p - (1-p) = 8p-1$	M1		2 correct unsimplified
	$C_3 : 3p + (1-p) = 1-4p$	A1		All correct
		M1		Plotting 3 expected gains for $0 \le p \le 1$
		A1		Correct gains plotted accurately
	Solving $8p - 1 = 1 - 4p$	M1		Choosing highest point of their region or correct
	$\Rightarrow p = \frac{1}{6}$	A1		
	$\Rightarrow$ Russ plays R_1 with probability $\frac{1}{6}$ and R_2 with prob $\frac{5}{6}$	E1	7	
(ii)	Value of game $= \frac{8}{6} - 1$ $= \frac{1}{3}$	B1	1	Or $1 - \frac{4}{6}$
	Total		**12**	

MD02 (cont)

Q	Solution	Marks	Total	Comments
4(a)(i)	Slack (variables)	E1	1	Must be correct word
(ii)	$2x + 2y + z + s = 14$	B1	1	Exactly this
(b)(i)	Pivot from y-column = 1	B1		Identified or seen used by keeping 3rd row fixed
	$\begin{matrix} 1 & -6 & 0 & 5 & 0 & 4 & 0 & 24 \\ 0 & 4 & 0 & -3 & 1 & -2 & 0 & 2 \\ 0 & -1 & 1 & 2 & 0 & 1 & 0 & 6 \\ 0 & 8 & 0 & -5 & 0 & -4 & 1 & 5 \end{matrix}$	M1		Row operations, even with wrong pivot
		A1		1st, 2nd or 4th row correct
		A1	4	All correct
(ii)	Still negative value in top row	E1	1	(only award if this is true for their tableau)
(c)(i)	Choosing 4 as pivot in x-column	M1		And perhaps dividing by 4 (using their pivot)
	$\begin{matrix} 1 & 0 & 0 & \frac{1}{2} & \frac{3}{2} & 1 & 0 & 27 \\ 0 & 1 & 0 & \frac{-3}{4} & \frac{1}{4} & \frac{-1}{2} & 0 & \frac{1}{2} \\ 0 & 0 & 1 & \frac{5}{4} & \frac{1}{4} & \frac{1}{2} & 0 & \frac{13}{2} \\ 0 & 0 & 0 & 1 & -2 & 0 & 1 & 1 \end{matrix}$	A1		1st, 3rd or 4th row correct ft one slip
		A1		1st, 3rd or 4th row (another correct) ft one slip
		A1	4	All correct (condone multiples of rows)
(ii)	Optimum now reached (since no negatives in top row)	E1		Or maximum value of P indicated (must have no negatives in top row)
	$P = 27$	B1√		ft their tableau P
	$x = \frac{1}{2},\ y = 6\frac{1}{2},\ z = 0$	B1	3	CAO; final tableau "correct" one slip
	Total		**14**	
5	July values	B1		3 correct unsimplified
		B1		Another 3 correct
		B1		All correct
	Use of one July min in June calculation	M1		
		A1		4 correct values in June
		A1		All June values correct (ft one slip)
	Use of two June min values in May calculation	M1		
		A1		All May correct (ft one slip)
				Equivalent scheme for Network Method working backwards from August
	Their least May value ⇒ Project for May	M1		
	May June July August *C* *A* hol *B*	A1	10	Schedule correct
				SC B1 if schedule correct with no dynamic programming

MD02 (cont)

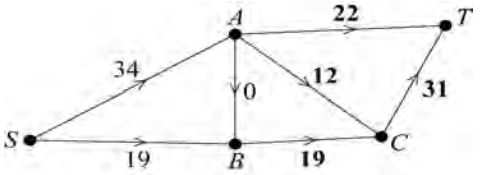
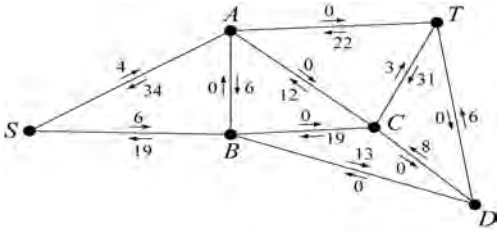
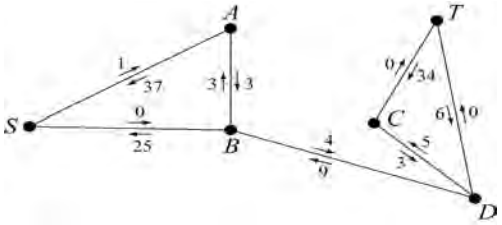
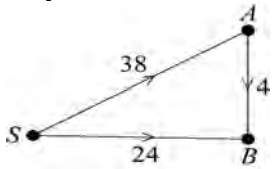
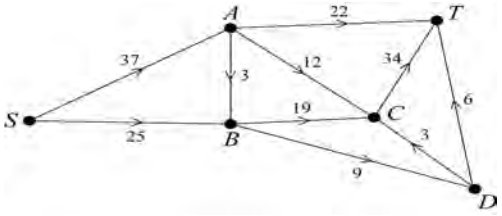
Q	Solution	Marks	Total	Comments
5 (cont)				

Stage (Month)	**State (Projects already done)**	**Action (Project to do)**	**Calculation**	**Cost in thousands of pounds**
August	*A, B, C*	0		0 (given)
	A, B	*C*		14 (given)
	A, C	*B*		10 (given)
	B, C	*A*		16 (given)
July	*A, B*	0	0 + 14	14 (given) ←
		C	15 + 0	15 (given)
	A, C	0	0 +10	10 ←
		B	12 + 0	12
	B, C	0	0 + 16	16 ←
		A	18 + 0	18
	A	*B*	12 + 14	26(given)
		C	15 + 10	25 ←
	B	*A*	18 + 14	32
		C	15 + 16	31 ←
	C	*A*	18 + 10	28 ←
		B	12 + 16	28 ←
June	*A*	0	0 + 25	25 ←
		B	13 + 14	27
		C	17 + 10	27
	B	0	0 + 31	31
		A	16 + 14	30 ←
		C	17 + 16	33
	C	0	0 + 28	28
		A	16 + 10	26 ←
		B	13 + 16	29
	0	*A*	16 + 25	41 ←
		B	13 + 31	44
		C	17 + 28	45
May	0	0	0 + 41	41
		A	17 + 25	42
		B	14 + 30	44
		C	14 + 26	40 ←

Schedule				
	May	**June**	**July**	**August**
Project	*C*	*A*	holiday	*B*

	Total		**10**	

MD02 (cont)

Q	Solution	Marks	Total	Comments
6(a)(i)	Value of cut = 38 + 25 + 0 + 0 + 34 = 97	B1	1	Must show correct addition AG
(ii)	$\{S, A\}$, $\{B, C, T\}$ 65	B1		
	$\{S, B\}$, $\{A, C, T\}$ 57	B1		
	$\{S, B, C\}$, $\{A, T\}$ 72	B1		
	$\{S, A, B, C\}$, $\{T\}$ 56	B1	4	
(iii)	Maximum flow = 53	B1√		ft their least cut value
	Minimum cut = Max flow	E1	2	
(iv)	Their max flow on *SA*, *SB* or *AT*, *CT*	M1		
	All correct AT 22; AC 12; BC 19; CT 31 $AB = x$; $AS = x + 34$; $SB = 19 - x$ $0 \le x \le 4$	A1	2	
(b)(i)	Initial flow on Figure 6 Forward potential and backward flow Condone 2 slips, ft their Figure 5	M1		
	One correct augmented path in table and correct flow	M1		
	Table correct with total additional flow= 9	A1		
	Final network correct with evidence of labelling procedure used	A1	4	
(ii)	New maximum flow = 62	B1		
	Correct maximum flow on network May have 	B1	2	
	Total		**15**	
	TOTAL		**75**	

Path	Additional Flow
SBDT	6
SABDCT	3