Version 1.0

General Certificate of Education (A-level)
June 2011

Mathematics MD02

(Specification 6360)

Decision 2

Final

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 events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process 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 standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

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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.

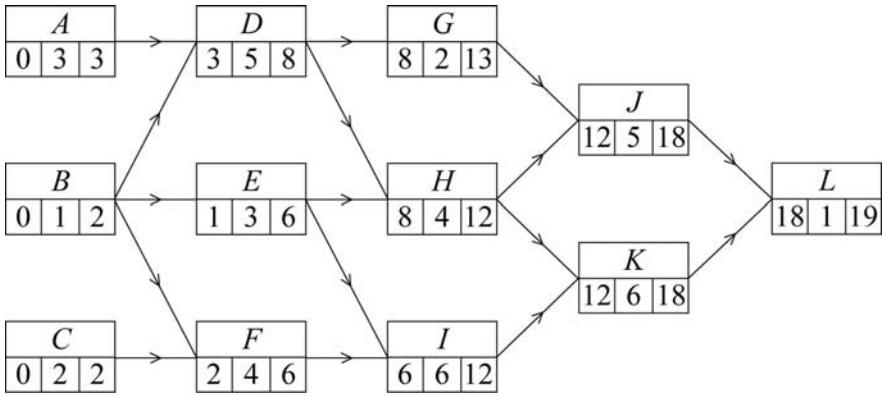
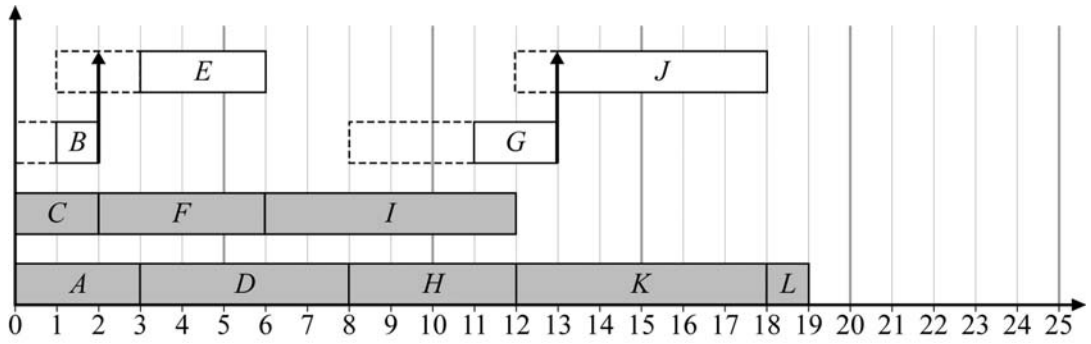
Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn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

MD02

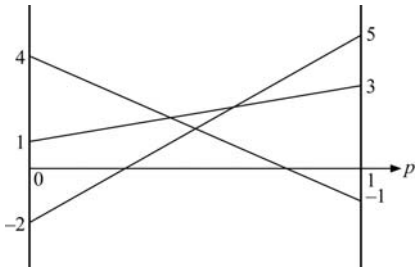
Q	Solution	Marks	Total	Comments
1(a)				
	Earliest start times	M1 A1		condone one slip + ft all correct
	Latest finish times	M1 A1	4	condone one slip + ft all correct
(b)	Critical paths *A D H K L* *C F I K L* Minimum time = 19	B1 B1 B1	3	one path correct second path correct and no others 19 days
(c)	Greatest float time at *G* $(13-8-2)=3$ (days)	M1 A1cso	2	ft their activity with greatest float for M1 values at *G* must be correct
(d)	*A*, *D*, *H*, *K*, *L* and *C*, *F*, *I* *B*, *E*, *G*, *J* *B(1-2); E(3-6); G(11-13); J(13-18)*	M1 A1 M1 A1cso	4	one of 'their' critical paths "correct" all 8 of these activities correct 3 of these with correct duration and latest start time (may omit slack) all 4 correct with correct slack shown
				
	Total		**13**	

MD02 (cont)

Q	Solution	Marks	Total	Comments
2(a)				
	3 1 0 4 1 1 4 1 2 4 1 0 3 1 2 2 3 2 0 0 0 5 1 2 1	M1		reducing columns first
	3 1 0 4 1 0 *k* 0 1 3 1 0 3 1 2 2 3 2 0 0 0 5 1 2 1	A1cso	2	then rows *k* = 3 stated or value 3 in table **AG**
(b)(i)	Lines through columns 1, 2, 3 and row 4	B1	1	
(ii)	3 1 0 3 0 0 3 0 0 2 1 0 3 0 1 3 4 3 0 0 0 5 1 1 0	M1 A1	2	subtract 1 from all uncovered and add 1 to all double covered (condone one slip) all correct ISW
	This now requires 5 lines to cover zeros			
(c)	*A2 B3 C1 D4 E5*	B1		one of these correct
	A5 B3 C1 D2 E4	B1		second way correct
	A5 B3 C2 D4 E1	B1	3	third way correct and no others
(d)	Minimum total = 68 (mins)	B1	1	
(e)	Replace each element x by $N - x$	E1	1	any value of N
	Total		**10**	

Q	Solution	Marks	Total	Comments
3(a)	Row minima are $-4, -3, -7$	M1		**both** row minima **and** column maxima attempted (condone 2 errors)
	Column maxima are $-3,\ 6,\ 8$	A1		all values correct
	max (row min) = min (col max) $= -3$	E1		condone arrows pointing to this element but must **state** max (row min) and min (col max) or equivalent
	Play-safe Tom **II** and Jerry **A**	B1	4	

MD02 (cont)

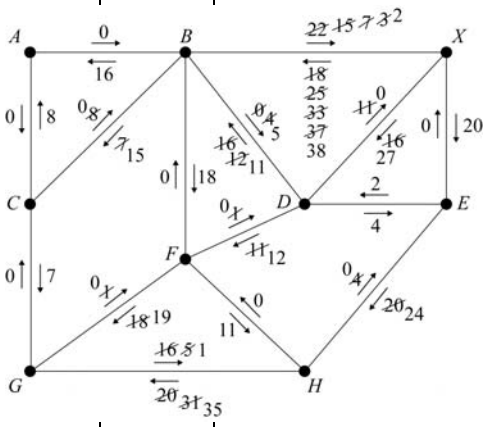
Q	Solution	Marks	Total	Comments
3(b)(i)	Let Rohan play R_1 with prob p $\Rightarrow$ plays R_2 with prob $1-p$			
	When Carla plays C_1, Rohan's expected gain $= 3p + (1-p)$ $= 1 + 2p$			
	$C_2 : 5p + (-2)(1-p) = 7p - 2$	M1		at least 2 expected gains correct unsimplified
	$C_3 : -p + 4(1-p) = 4 - 5p$	A1		all 3 correct unsimplified
		M1		at least 2 lines correct
		A1		all lines correct for $0 \leqslant p \leqslant 1$ and values at 0 and 1 clear
				choosing highest point
	$7p - 2 = 4 - 5p$ $12p = 6$	M1		or using correct equation
	$\Rightarrow p = \frac{1}{2}$ $\Rightarrow$ Rohan plays R_1 50% of the time and R_2 50% of the time	A1cso		
	Value of game $= 7 \times \frac{1}{2} - 2 = \frac{3}{2}$ AG	B1	7	or $4 - \frac{5}{2} = \frac{3}{2}$ must see working
(b)(ii)	When Rohan plays R_1, expected loss for Carla is $3p + 5q + (-1)(1-p-q)$			
	and when Rohan plays R_2, expected loss for Carla is $p + (-2)q + 4(1-p-q)$	M1		either expression correct unsimplified
	$4p + 6q = \frac{3}{2} + 1$ $3p + 6q = 4 - \frac{3}{2}$	A1		correct simultaneous equations unsimplified
	$\Rightarrow p = 0,\ q = \frac{5}{12}$	A1		condone 0.42 or better
	$\Rightarrow$ Carla never plays C_1, plays C_2 with prob $\frac{5}{12}$ and plays C_3 with prob $\frac{7}{12}$	E1cso	4	Must have all 3 correct probabilities
	Total		**15**	

MD02 (cont)

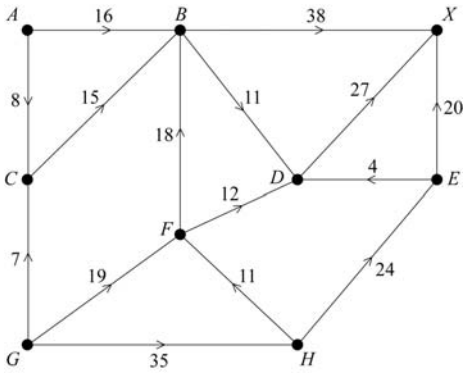
Q	Solution	Marks	Total	Comments
4(a)	$5x+3y+10z \leqslant 15$ $7x+6y+4z \leqslant 28$ $4x+3y+6z \leqslant 12$	M1 A1	 2	2 inequalities correct or all 3 LHS & RHS correct but using $<$ all correct
(b)(i)	Choosing 3 from bottom row as pivot	B1		identified or used
	$1 \quad 6 \quad 0 \quad 12-k \quad 0 \quad 0 \quad 2 \quad 24$ $0 \quad 1 \quad 0 \quad 4 \quad 1 \quad 0 \quad -1 \quad 3$	M1		row operations (even with wrong pivot)
	$0 \quad -1 \quad 0 \quad -8 \quad 0 \quad 1 \quad -2 \quad 4$	A1		one of rows 1, 2, 3 correct
	$0 \quad \frac{4}{3} \quad 1 \quad 2 \quad 0 \quad 0 \quad \frac{1}{3} \quad 4$	A1	4	all correct (condone multiples of rows)
(ii)	$12-k<0$ $\Rightarrow k>12$	M1 A1	 2	their '$12-k$' <0 SC B1 for $k \geqslant 13$
(c)(i)	$1 \quad 6 \quad 0 \quad -8 \quad 0 \quad 0 \quad 2 \quad 24$ $0 \quad 1 \quad 0 \quad 4^* \quad 1 \quad 0 \quad -1 \quad 3$ $0 \quad -1 \quad 0 \quad -8 \quad 0 \quad 1 \quad -2 \quad 4$ $0 \quad \frac{4}{3} \quad 1 \quad 2 \quad 0 \quad 0 \quad \frac{1}{3} \quad 4$	M1		correct pivot from z column 4* (identified or used)
	$1 \quad 8 \quad 0 \quad 0 \quad 2 \quad 0 \quad 0 \quad 30$ $0 \quad \frac{1}{4} \quad 0 \quad 1 \quad \frac{1}{4} \quad 0 \quad -\frac{1}{4} \quad \frac{3}{4}$ $0 \quad 1 \quad 0 \quad 0 \quad 2 \quad 1 \quad -4 \quad 10$ $0 \quad \frac{5}{6} \quad 1 \quad 0 \quad -\frac{1}{2} \quad 0 \quad \frac{5}{6} \quad \frac{5}{2}$	A1 A1 A1	 4	one of rows 1, 3 or 4 correct another of rows 1, 3 or 4 correct all correct (condone multiples of rows)
(ii)	Maximum value of P now reached	E1		their tableau must have no negatives in top row
	$P=30,\ x=0,\ y=\frac{5}{2},\ z=\frac{3}{4}$	B1√		ft their values from their tableau provided at least 2 marks earned in (c)(i)
	$s=0,\ t=10,\ u=0$	B1cao	3	condone up to 2 slips in their final tableau
	Total		**15**	

MD02 (cont)

Q	Solution	Marks	Total	Comments
5(a)	Cut value $= 40 + 27 + 0 + 24$ $= 91$	B1	1	
(b)	*ABDX* 16 *GFBX* 18 *GHEX* 20	B1 B1 B1	3	
(c)(i)	One correct route with additional flow	M1		any feasible route and flow
	Another 2 routes and flows correct	A1		total flow at least 80
	All routes correct with total flow = 85	A1cso		
	Forward and backward flows on diagram (directions must be clear)	M1		at least 8 edges with pairs of values 'correct'
	Augmenting flows	A1cso	5	correct
	Consider other possible correct flows *Condone diagram as shown but really should have initial flows in DE, etc*			
(ii)	Max flow = 85	B1		
	Correct max flow	B1	2	
	Consider other possible correct flows			
(d)	Considering 'their' *AB*+*CB*+*FB* – 45 = 4 fewer ⇒ max number = 81	M1 A1cao	2	
	Total		**13**	



Route	Flow
ABDX	16
GFBX	18
GHEX	20
GCBX	7
ACBX	8
GHFDX	11
GHEDBX	4
GFDBX	1



MD02 (cont)

Q	Solution	Marks	Total	Comments
6	Wednesday profits	M1		4 more calculations/ profits correct
		A1		6 more profits correct
		A1		all profits correct
	Tuesday: use of maxima from Wednesday	M1		6 more calculations/profits correct
		A1		8 profits correct
		A1√		all profits correct ft one slip from Wednesday figures
	Monday values correct	A1√		all profits correct ft one slip from Tuesday figures
	(Monday builds shed) *D*	M1		Choosing largest Monday profit from their table
	⇒ order *D B A C*	A1cso	9	SC B1 only for order *D B A C* NMS or without "correct" table

Stage (Day)	State (Sheds already built)	Action (shed to build)	Calculation	Profit in pounds	
Thursday	*A, B, C*	*D*		90	
	A, B, D	*C*		87	
	A, C, D	*B*		76	
	B, C, D	*A*		70	
Wednesday	*A, B*	*C*	84 + 90	174	
		D	88 + 87	175	→
	A, C	*B*	71 + 90	161	→
		D	82 + 76	158	
	A, D	*B*	74 + 87	161	→
		C	83 + 76	159	
	B, C	*A*	65 + 90	155	
		D	86 + 70	156	→
	B, D	*A*	69 + 87	156	→
		C	85 + 70	155	
	C, D	*A*	66 + 76	142	
		B	73 + 70	143	→
Tuesday	*A*	*B*	72 + 175	247	→
		C	83 + 161	244	
		D	84 + 161	245	
	B	*A*	60 + 175	235	
		C	80 + 156	236	
		D	83 + 156	239	→
	C	*A*	57 + 161	218	
		B	68 + 156	224	
		D	85 + 143	228	→
	D	*A*	62 + 161	223	
		B	70 + 156	226	→
		C	81 + 143	224	
Monday	-	*A*	50 + 247	297	
		B	65 + 239	304	
		C	70 + 228	298	
		D	80 + 226	306	→

Schedule

	Monday	Tuesday	Wednesday	Thursday
Shed to build	*D*	*B*	*A*	*C*

	Total		**9**	
	TOTAL		**75**	