A-Level

Mathematics

MD02 Decision 2

Final Mark scheme

6360

June 2017

Version/Stage: 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.

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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.

Q1	Solution	Mark	Total	Comment
a	Only 'non-negatives' in profit row oe	**E1**	**1**	
b	$P = 20$	**B1**		
	$x = 6,\ y = 0,\ z = 1$	**B1**		
	$r = 0,\ s = 0.25,\ t = 0$	**B1**	**3**	
	Total		**4**	

Notes:
Do not accept 'positive', but do accept 'all positive or zero'

Q2	Solution	Mark	Total	Comment
	Erica: Row min (–2, –4, –2, –3) Max(rowmin) = –2	**B1***		Earned here, all correct 4 values seen and at least one –2 highlighted or stated.
	Playsafe Erica = A, C	**B1**		Both needed, and no others
	Viggo: Col max (4, 0, 3, 4) Min(colmax) = 0	**(B1*)**		Or here, all correct 4 values seen and 0 highlighted or stated
	Playsafe Viggo = X	**B1**		And no others
	Max(rowmin) [= -2] $\neq$ [0 =] Min(colmax) There is no stable soln	**E1**		Must have statement and conclusion Must see 'Max(rowmin) = –2' and 'Min(colmax) = 0', either here or earlier in their solution
	Total		**4**	

Notes:

If a candidate has used (complete) dominance:
A > D
then X > Z
then A > B
then Y > W
Erica: Max(rowmin) (–2, –2) = –2 (**B1*** here)
play-safe A, C (**B1**)
Viggo: Min (colmax) (0, 3) = 0 (**B1*** or here)
play-safe X (**B1**)
Conclusion as above (**E1**)
If a candidate has started dominance and then stopped after A > D etc, then their numbers will reflect the size of their reduced matrix ie every use of dominance reduces their rowmin or colmax by 1 value
The **E1** mark is not FT

Q 3	Solution	Mark	Total	Comment
(a)	Reduce rows: 7 17 17 7 0 10 x - 20 0 10 5 4 9 0 7 9 7 5 10 10 0 2 0 1 2 4	**M1**		All correct, condone up to 2 slips
	Reduce cols 5 17 17 5 0 8 x - 20 0 8 5 2 9 0 5 9 5 5 10 8 0 ~~0 0 1 0 4~~	**A1**		All correct
	Covered with exactly 3 lines, reduce by 2 3 15 17 3 0 6 x - 22 0 6 5 0 7 0 3 9 3 3 10 6 0 ~~0 0 3 0 6~~	**dM1**		Subtract 2 from all uncovered, add 2 to all 'double' covered, leave single covered unaltered (condone 1 slip)
	Covered with exactly 4 lines, reduce by 3 (other lines possible) ~~3 12 17 0 0~~ ~~6 x - 25 0 3 5~~ ~~0 4 0 0 9~~ ~~3 0 10 3 0~~ ~~3 0 6 0 9~~	**dM1** **A1**		Subtract 3 from all uncovered, add 3 to all 'double' covered, leave single covered unaltered (condone 1 slip) All correct – other correct final tables shown below
	Covered by **exactly** 5 lines, so optimal OE	**E1**		Must see this line
	Match AX, BY, CW, DZ, EV AX, BZ, CW, DV, EY	**B1** **B1**		One correct match Second correct match and no others
	Time 75 (mins)	**B1**		
	Total		**9**	

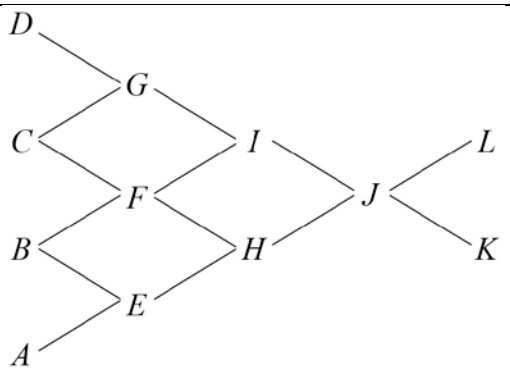
Notes:

Other possible correct final tables

'Working' might be in extra stages eg reduce by 1 and then again reduce by 1 – ignore extra steps

~~0~~	~~12~~	~~17~~	~~0~~	~~0~~
~~3~~	~~x - 25~~	~~0~~	~~3~~	~~5~~
~~0~~	~~7~~	~~3~~	~~3~~	~~12~~
~~0~~	~~0~~	~~10~~	~~3~~	~~0~~
~~0~~	~~0~~	~~6~~	~~0~~	~~9~~

~~0~~	~~12~~	~~14~~	~~0~~	~~0~~
~~6~~	~~x - 22~~	~~0~~	~~6~~	~~8~~
~~0~~	~~7~~	~~0~~	~~3~~	~~12~~
~~0~~	~~0~~	~~7~~	~~3~~	~~0~~
~~0~~	~~0~~	~~3~~	~~0~~	~~9~~

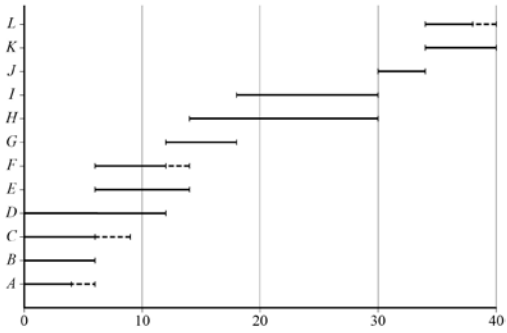
<table>
<tr><th>Q4</th><th>Solution</th><th>Mark</th><th>Total</th><th>Comment</th></tr>
<tr><td>(a)</td><td> 
</td><td>M1

A1</td><td>2</td><td>Network diagram, 11+ connected activities

All correct
(condone ‘extra end’ activity)</td></tr>
<tr><td>(b)(i)</td><td>
<table>
<tr><th>Task</th><th>Early</th><th>Late</th></tr>
<tr><td>A</td><td>0</td><td>6</td></tr>
<tr><td>B</td><td>0</td><td>6</td></tr>
<tr><td>C</td><td>0</td><td>12 or 14–x</td></tr>
<tr><td>D</td><td>0</td><td>12</td></tr>
<tr><td>E</td><td>6</td><td>14</td></tr>
<tr><td>F</td><td>6</td><td>14</td></tr>
<tr><td>G</td><td>12</td><td>19</td></tr>
<tr><td>H</td><td>14</td><td>30</td></tr>
<tr><td>I</td><td>19</td><td>30</td></tr>
<tr><td>J</td><td>30</td><td>34</td></tr>
<tr><td>K</td><td>34</td><td>40</td></tr>
<tr><td>L</td><td>34</td><td>40</td></tr>
</table>
</td><td>M1
A1

M1

A1ft</td><td></td><td>Early times SCA, correct at E, F, G
All correct

Late times, correct at E, F, G from their final total time
All correct, from their 40, must have both ‘terms’ at C
only if no answers are nonsensical
ie early time + duration cannot exceed late time</td></tr>
<tr><td>(ii)</td><td>BEHJK
DGIJK</td><td>B1</td><td>5</td><td>Both critical paths correct and no extras</td></tr>
<tr><td>(c)(i)</td><td>$32 + x$</td><td>M1
A1</td><td></td><td>$x + k$, where $k \geq 32$</td></tr>
<tr><td>(ii)</td><td>2</td><td>B1</td><td>3</td><td></td></tr>
<tr><td>(d)</td><td> 
</td><td>M1
B1
A1</td><td>3</td><td>SCA, at least 10 labelled activities
Use of floats, at least 2 of A, C, F, L
All correct, including labelling and all floats correct</td></tr>
<tr><td></td><td>Total</td><td></td><td>13</td><td></td></tr>
</table>

Notes:

(d) For a correct, but different, Gantt diagram, the **M1** can only be scored for 10+ activities labelled **AND**; a critical path on one row, all other critical activities on a second row (and nothing else), and each non-critical activity on its own row. The **A** mark is as above.

The floats may be before the activity or after the activity

Q5	Solution	Mark	Total	Comment

P	x	y	z	r	s	t	V
1	-2	3	-5	0	0	0	0
0	3	-2	**2**	1	0	0	44
0	4	2	-1	0	1	0	44
0	5	1	-4	0	0	1	44

B1 3 rows correct

B1 All correct

Row 2 in z-col as pivot

E1 '2' highlighted

2	11	-4	0	5	0	0	220
0	3	-2	2	1	0	0	44
0	11	**2**	0	1	2	0	132
0	11	-3	0	2	0	1	132

M1 SCA – row reduction, 2+ rows correct

A1 All correct

Row 3 in y-col as pivot

E1 '2' highlighted

2	33	0	0	7	4	0	484
0	14	0	2	2	2	0	176
0	11	2	0	1	2	0	132
0	55	0	0	7	6	2	660

dM1 SCA – row reduction, 3+ rows correct

A1 All correct

'Profit row' must only contain non-negatives for the following marks to be available

Max $P = 242$

B1 Must include 'max/optimal'

$x = 0$, $y = 66$, $z = 88$, $r = 0$, $s = 0$, $t = 330$

B1 All stated

	Total		**10**	

Notes:

In all tables, the rows can be a multiple of the given answer – see below

Slack variables may be different to r, s, t (possibly s, t, u, in which case $t = 0$ and $u = 330$)

Eg reducing the pivots to 1

P	***x***	***y***	***z***	***r***	***s***	***t***	***V***
1	-2	3	-5	0	0	0	0
0	3	-2	2	1	0	0	44
0	4	2	-1	0	1	0	44
0	5	1	-4	0	0	1	44

1	11/2	-2	0	5/2	0	0	110
0	3/2	-1	1	1/2	0	0	22
0	11/2	1	0	1/2	1	0	66
0	11	-3	0	2	0	1	132

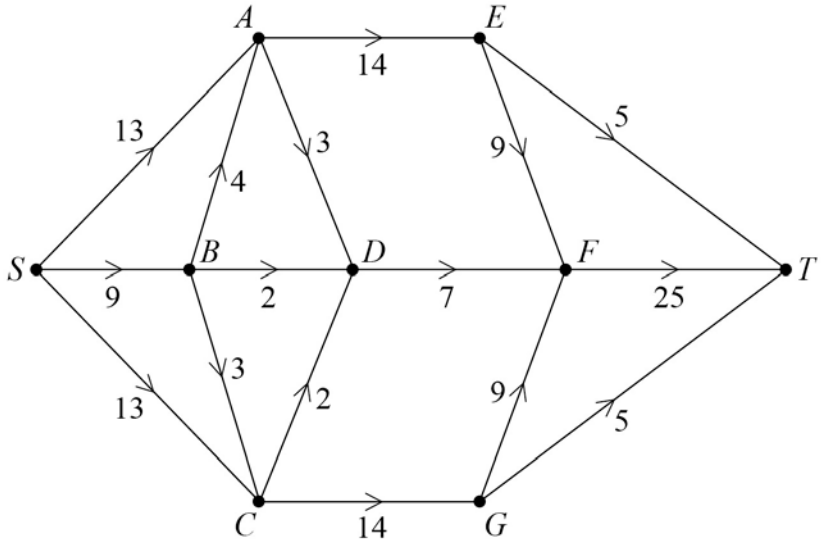
1	33/2	0	0	7/2	2	0	242
0	7	0	1	1	1	0	88
0	11/2	1	0	1/2	1	0	66
0	55/2	0	0	7/2	3	1	330

Q6	Solution	Mark	Total	Comment
	(J never plays B as) A dominates B J plays A with prob p, and C with prob 1-p	**E1**		
	Nigel plays D, J wins $3p-1(1-p)=4p-1$ plays E, J wins $p+2(1-p)=2-p$	**M1**		Any expression correct, in either simplified/unsimplified form
	plays F, J wins $-2p+4(1-p)=4-6p$	**A1**		All 3 correct, in either simplified/unsimplified form
	Graph, at least one vertical axis, with scale labelled, and 3 ruled 'diagonal' lines	**M1**		
	Ruled line connecting -1 to 3 Ruled line connecting 2 to 1 Ruled line connecting 4 to -2	**A1**		All 3 lines correct, 2 vertical axes, including scales on both axes
	[Max point at] $4p-1=4-6p$ $[p=0.5]$	**M1**		
	Jeremy plays A with prob 0.5 Jeremy plays B with prob 0 Jeremy plays C with prob 0.5	**A1**		Must have all 3 statements
	(Value of game for J = 1) Value of game for Nigel = –1	**B1**		Must be clear that their answer is value of game for Nigel
	Total		**8**	

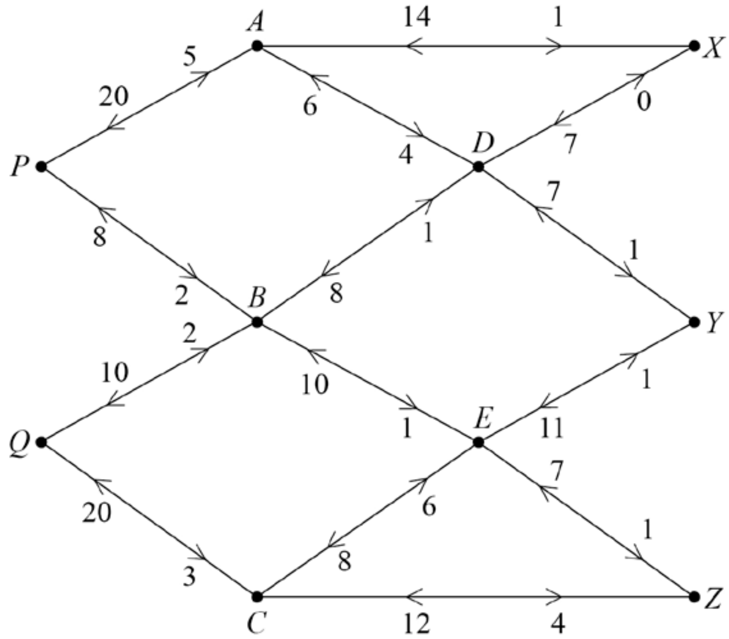
Notes:
Candidate might have said 'never plays B' at start for final **A1**

Q7	Solution					Mark	Total	Comment
	Stage	State	From	Calculation	Value			
	1	*J*	*T*		20			
		K	*T*		18			
	2	*G*	*J*	(30 + 20)	50 (*)			
		H	*J*	(22 + 20)	42			
		H	*K*	(25 + 18)	43 *			
		I	*K*	(26 + 18)	44 (*)	**M1**		their max at *H* indicated
						A1		All 4 values correct
	3	*C*	*G*	(50 – 8)	42 (*)			
		D	*G*	(50 – 12)	38	**B1**		8 values
		D	*H*	(43 – 4)	39			
		D	*I*	(44 – 4)	40 *	**dM1**		their max values at *D* and *E* indicated
		E	*G*	(50 – 10)	40			
		E	*H*	(43 – 4)	39			
		E	*I*	(44 – 3)	41 *			
		F	*I*	(44 – 7)	37 (*)			
						A1		All 8 values correct
	4	*A*	*C*	(42 + 17)	59			
		A	*D*	(40 + 18)	58	**B1**		6 values
		A	*E*	(41 + 19)	60 *			
		B	*D*	(40 + 18)	58 *			
		B	*E*	(41 + 17)	58 *			
		B	*F*	(37 + 20)	57	**A1**		All 6 values correct including two '58' and '60' indicated
	5	*S*	*A*	(60 + 19)	79			
		S	*B*	(58 + 22)	80 *	**A1**		Both values correct, including 80 indicated Or stated Max = £80
	Routes SBDIKT					**B1**		A correct route
	SBEIKT					**B1**		2nd correct route and no others
					Total		**10**	

Notes:
For dM1 a candidate may have more than 4 'max' ie duplicate values

Q8	Solution	Mark	Total	Comment
(a)(i)	37	**B1**		
(ii)	43	**B1**	**2**	
(b)(i)	Min flow leaving B is 4 + 2 + 3	**E1**		Need 'min' and 4, 2, 3
(ii)	25	**B1**	**2**	
(c)				
	SB, BA, BD, BC, DF, EF, GF, FT correct	**B1**		ie correct at *B* and *F*
	SC, SA, AD, AE, CD, CG, ET, GT correct	**B1**	**2**	
	Total		**6**	

Notes:
(c) condone omission of 'arrows'

<table>
<tr><th>Q9</th><th>Solution</th><th>Mark</th><th>Total</th><th>Comment</th></tr>
<tr><td>(a)</td><td>Adding edges SP, SQ, XT, YT, ZT</td><td>B1</td><td></td><td>S and T must be clearly labelled
If other label(s) used, only penalise here</td></tr>
<tr><td></td><td></td><td></td><td>1</td><td></td></tr>
<tr><td>(b)</td><td> 
</td><td>M1

A1

A1</td><td>3</td><td>Correct values of potential increases and decreases at one of PA, PB, QB, QC

Correct increases and decreases, including directions at both AX and DX
or
both EZ and CZ

All correct</td></tr>
<tr><td>(c)</td><td><table><tr><th>Route</th><th>Flow</th></tr><tr><td>SPAXT</td><td>1</td></tr><tr><td>SPADYT</td><td>1</td></tr><tr><td>SPBEYT</td><td>1</td></tr><tr><td>SQCZT</td><td>3</td></tr><tr><td>Total</td><td>6</td></tr></table>
All augmentations correctly showing an increase of 6 on diagram</td><td>M1
A1
A1

A1

A1</td><td>5</td><td>One correct flow, including value
2nd correct flow, including value
3rd correct flow, including value

All correct, including values, that must total to 6
(there are other correct flows equivalent to these flows)

Must have scored at least M1A1 in (b)</td></tr>
<tr><td>(d)</td><td>Max flow = 64
Cut through AX, DX, DY, BE, QC</td><td>B1
B1</td><td>2</td><td>
Must be listed</td></tr>
<tr><td></td><td>Total</td><td></td><td>11</td><td></td></tr>
</table>

Notes:

(c) The *SQC_T* flow can only score 1 mark, even if it is split into 2 or 3 augmentations of 1

The options should follow the following pattern (in any order)

Route	Flow
S_AXT	1
S_DYT	1
S_BE_T	1
SQC_T	3
Total	6