OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 4737

Decision Mathematics 2

MARK SCHEME

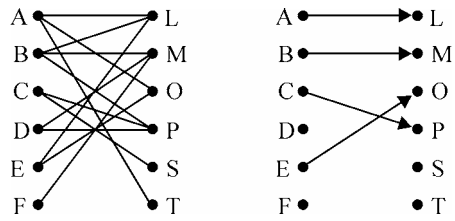
Specimen Paper

MAXIMUM MARK	72

This mark scheme consists of 5 printed pages and 3 blank pages.

 Registered Charity Number: 1066969 **[Turn over**

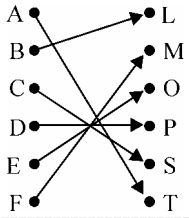
1 **(i)**



M1 For attempt at the bipartite graph
A1 For correct graph
B1 **3** For the correct incomplete matching

(ii) Alternating paths are:

S–C=P–D and T–A=L–B=M–F
or S–C=P–B=M–D and T–A=L–B=P–D=M–F
or S–C=P–B=M–F and T–A=L–B=P–D
or T–A=L–B=M–D and S–C=P–D=M–F
or T–A=L–B=M–F and S–C=P–D



M1 For attempt at an alternating path
A1 For one correct path
A1 For the second path correcct
B1 **4** For correct matching

(iii)

	A	B	C	D	E	F
L	0	0	1	1	0	1
M	1	0	1	0	1	0
O	0	1	1	1	0	1
P	1	0	0	0	1	1
S	1	1	0	1	1	1
T	0	1	1	1	1	1

M1 For appropriate zeros and ones (e.g.) to correspond with minimum cost matching
A1 **2** For a correct table

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2 **(i)** Adding a dummy column gives

$$\begin{matrix}4&3&2&4&6\\3&5&4&2&6\\3&6&3&3&6\\2&6&4&3&6\\2&5&3&4&6\end{matrix}$$

B1 For a dummy column (equal entries, $\geqslant 6$)

Reducing:
$$\begin{matrix}2&1&0&2&4\\1&3&2&0&4\\0&3&0&0&3\\0&4&2&1&4\\0&3&1&2&4\end{matrix}$$ then $$\begin{matrix}2&0&0&2&1\\1&2&2&0&1\\0&2&0&0&0\\0&3&2&1&1\\0&2&1&2&1\end{matrix}$$

M1 For reducing rows
M1 For reducing columns
M1 For covering zeros in the reduced matrix

Four lines are needed to cover zeros

Augmenting:
$$\begin{matrix}3&0&0&3&1\\1&1&1&0&0\\1&2&0&1&0\\0&2&1&1&0\\0&1&0&2&0\end{matrix}$$ or $$\begin{matrix}3&0&0&2&1\\2&2&2&0&1\\1&2&0&0&0\\0&2&1&0&0\\0&1&0&1&0\end{matrix}$$

M1 For correct augmentation process

Hence Adam–Glasgow and Betty–Swansea
and either Clive–Manchester, Dave–London
or Clive–Manchester, Eleanor–London
or Dave–London, Eleanor–Manchester

A1 For these two allocations correct
A1 **7** For any one of the correct possibilities

(ii) Without Betty, reduced matrix is

$$\begin{matrix}2&0&0&2\\0&2&0&0\\0&3&2&1\\0&2&1&2\end{matrix}$$

M1 For new reduced matrix

Hence either Adam–Glasgow, Clive–Swansea,
Dave–London, Eleanor–Manchester
or Adam–Glasgow, Clive–Manchester,
Dave–Swansea, Eleanor–London

A1 **2** For either of the correct new possibilities

9

3 **(i)**

2	0	0	5	5
	1	0	7	7
	2	0	9	9
1	0	0	min(12, 5) = 5	7
		1	min(7, 7) = 7	
	1	1	min(8, 7) = 7	9
		2	min(10, 9) = 9	
	2	0	min(9, 5) = 5	9
		2	min(14, 9) = 9	
0	0	0	min(9, 7) = 7	8
		1	min(7, 9) = 7	
		2	min(8, 9) = 8	

Route is (0; 0)–(1; 2)–(2; 2)–(3; 0) — B1 — For correct route
Maximum number of crates is 8 — B1 **7** — For correct number

M1 — For dealing with route min column
A1 — For at least 6 minima correct
M1 — For dealing with maximin column
A1 — For Stage 1 section of table all correct
A1 — For completely correct table

(ii) New maximin values are 15, 7, 9, 12, 9, 9, 9 — M1 — For appropriate re-calculation
Hence new route is (0; 0)–(1; 0)–(2; 0)–(3; 0) — A1 — For correct new route
New maximum number of crates is 9 — A1 **3** — For correct number

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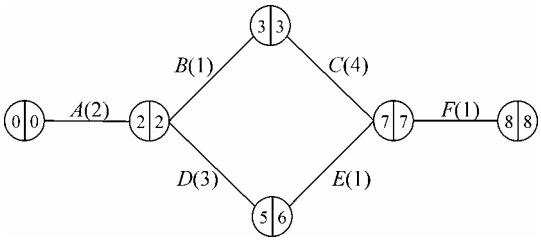
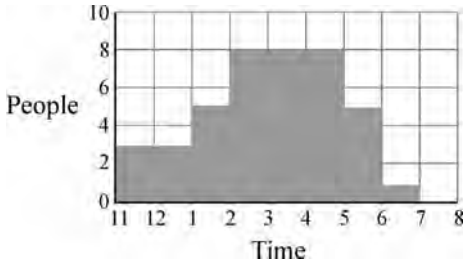
4 **(i)**



B1 — For correct arcs and activities (activity on arc network or equivalent with activity at node)
M1 — For correct process for forward pass
M1 — For correct process for reverse pass
A1 — For all early and late times correct

Minimum completion time is 8 hours — A1 — For correct minimum time stated
Critical activities are *A*, *B*, *C*, *F* — B1 — For correct critical activities
Start telephoning at 11.00 am — B1√ **7** — For stating the appropriate time of day

(ii)



M1 — For resource histogram with axes labelled
A1 — For correct heights 3, 3, 5, 8, 8, 8, 5, 1

Maximum number of people needed is 8 — B1 **3** — For correct number stated

(iii)

Time	H	1	2	3	4	5
10–11	*A*	*A*	*A*	*D*	*D*	*D*
11–12	*A*	*A*	*A*	*D*	*D*	*D*
12– 1		*B*	*B*	*D*	*D*	*D*
1– 2		*C*	*C*	*C*	*C*	*C*
2– 3		*C*	*C*	*C*	*C*	*C*
3– 4		*C*	*C*	*C*	*C*	*C*
4– 5		*C*	*C*	*C*	*C*	*C*
5– 6	*E*	*E*	*E*			
6– 7	*F*					

M1 — For substantially correct attempt
A1 — For a correct schedule

Start telephoning at 10.00 am — B1 **3** — For correct time stated

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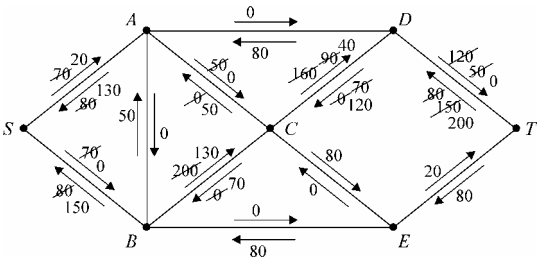
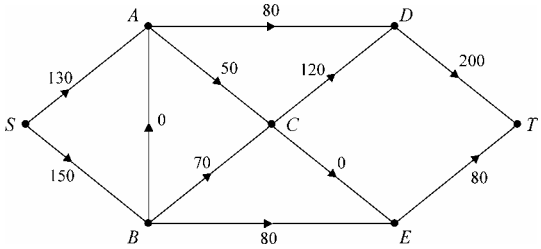
5	**(i)**	Capacity is $150+0+50+80=280$ litres/sec	M1 A1 **2**	For correct use of zero from *AB* For correct value 280
	(ii)	Maximum flow is $\leqslant 280$ So flow of $200+100=300$ is not possible	M1 A1 **2**	For relevant use of max flow/min cut For completely correct proof
	(iii)		M1 A1 A1 **3**	For correct method for excess and backflow For all initial excess capacities correct For all initial backflows correct
	(iv)	Augment by 70 along *SBCDT* (e.g.) New excesses and backflows are as shown above Now augment by 50 along *SACDT* (e.g.) Final excesses and backflows are as shown above	B1 M1 M1 A1 **4**	For identifying a correct augmentation For modifying excesses and backflows For continuing the process as far as possible For a completely correct solution
	(v)		B1√	For showing the augmented flow correctly
		The value of the augmented flow is 280 litres/sec, and so is the maximum possible	M1 A1 **3**	For comparing with results from **(i)** or **(ii)** For a completely correct explanation (Or equivalent explanation based on the disconnectedness of *S* and *T* in **(iii)**)
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6 **(i)**

	X	*Y*	*Z*	row min	
A	1	3	4	1	
B	4	3	2	2	←
C	3	2	1	1	
– col max	–4	–3	–4		
		↑			

Play-safe for Rose is *B* — B1 — For correct statement
Play-safe for computer is *Y* — B1 — For correct statement
Not stable as $-3+2\neq 0$ — B1 **3** — For use of max row min and min col max

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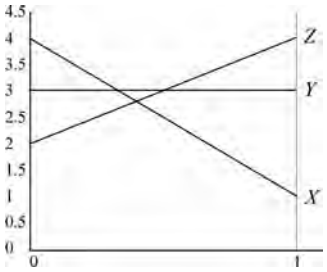
(ii) Row *C* is dominated by row *B* — B1 — For correct statement or explanation

	X	*Y*	*Z*
A	1	3	4
B	4	3	2

B1 **2** — For new matrix

(iii) Expected pay-off with *X* is $1\times a+4(1-a)=4-3a$ — B1 — For showing given answer correctly
and with *Y* is $3a+3(1-a)=3$ — B1 — For correct value 3
and with *Z* is $4a+2(1-a)=2+2a$ — B1 — For correct expression $2+2a$



B1√ — For correct diagram

Required value of *a* is 0.4 — B1√ — For correct value
Score of 1 or 2: play *A*; score of 3, 4 or 5: play *B*;
Throw die again if it shows a six — B1√ **6** — For a correct decision rule

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(iv)

	X	*Y*	*Z*
A	–1	–3	–4
B	–4	–3	–2

B1 — For correct pay-off matrix for the computer

Add 4 to each value — B1 **2** — For a correct explanation

(v) $z=0.6$ — B1 — For the correct value of *z*
$p=1.2\Rightarrow P=-2.8$ — B1 — For the correct values of both *p* and *P*
The computer should choose *X* with probability 0.4 and *Z* with probability 0.6 — B1 — For a correct description of the strategy
On average the computer will lose no more than 2.8 points per game — B1 **4** — For a correct interpretation of *P*

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