

Mark Scheme 4737

June 2006

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1	(i)	4+4+8+7+6 = 29 litres per second	B1 [1]	For 29
	(ii)	4-1-2+3+3+5 = 12 litres per second 0 - 5 - 4 + 3 + 0 + 5 = -1 So minimum flow across cut is 0	M1 A1 M1 A1 [4]	For using upper and lower capacities correctly For showing how 12 (given) was worked out For a substantially correct calculation For 0, from an appropriate calculation
	(iii)	Flow in arc CE ≥ 2 and flow in arc CF ≥ 3 , so at least 5 litres per second must flow into C At most 4 litres per second flow into A, of which at least 1 flows out to B and 2 flow out to E, so at most 1 litre per second can flow along AD	M1 A1 M1 A1 [4]	For any reasonable attempt (eg CE = 2, CF = 3) For correct reasoning For identifying ≤ 4 in and ≥ 3 out or equivalent For a correct conclusion
	(iv)	Either a diagram or a description of a flow of 11 litres per second. Arcs AD, AE, BE, CE, CF must all be at their minimum capacities.	M1 A1 A1 [3]	For a flow of 11 litres per second from S to T Flow satisfies all lower capacities Flow satisfies all upper capacities
	(v)	11 \leq maximum flow \leq 12	B1 B1 [2]	11 as lower bound 12 as upper bound (max flow = 12 \Rightarrow B0, B1)
				14

2	(i)	The route for which the minimum weight on the route is greatest				B1 B1 [2]	For identifying route minima For identifying what has been maximised (‘maximises the minimum’ ⇒ B0 B1)																																						
	(ii)	<table border="1"> <thead> <tr> <th>Stage</th> <th>State</th> <th>Action</th> <th>Working</th> <th>Maximin</th> </tr> </thead> <tbody> <tr> <td rowspan="3">1</td> <td>0</td> <td>0</td> <td></td> <td>18</td> </tr> <tr> <td>1</td> <td>0</td> <td></td> <td>15</td> </tr> <tr> <td>2</td> <td>0</td> <td></td> <td>15</td> </tr> <tr> <td rowspan="4">2</td> <td rowspan="2">0</td> <td>0</td> <td>min(16,18) =16</td> <td rowspan="2">16</td> </tr> <tr> <td>1</td> <td>min(13,15) =13</td> </tr> <tr> <td rowspan="2">1</td> <td>2</td> <td>min(14,15) =14</td> <td rowspan="2">18</td> </tr> <tr> <td>0</td> <td>min(19,18) =18</td> </tr> <tr> <td rowspan="2">3</td> <td rowspan="2">0</td> <td>0</td> <td>min(20,16) =16</td> <td rowspan="2">16</td> </tr> <tr> <td>1</td> <td>min(16,18) =16</td> </tr> </tbody> </table>				Stage	State	Action	Working	Maximin	1	0	0		18	1	0		15	2	0		15	2	0	0	min(16,18) =16	16	1	min(13,15) =13	1	2	min(14,15) =14	18	0	min(19,18) =18	3	0	0	min(20,16) =16	16	1	min(16,18) =16	B1 B1 [2]	Stage and state columns completed correctly Action column completed correctly
		Stage	State	Action	Working	Maximin																																							
1	0	0		18																																									
	1	0		15																																									
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2	0	0	min(16,18) =16	16																																									
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3	0	0	min(20,16) =16	16																																									
		1	min(16,18) =16																																										
(iii)	18 tonnes (3; 0) – (2; 0) – (2; 1) – (1; 0) – (0; 0)	B1 B1 [2]	For 18 For this route																																										

Maximin routes: (3; 0) – (2; 0) – (1; 0) – (0; 0)
 (3; 0) – (2; 1) – (1; 0) – (0; 0)
 Maximum load = 16 tonnes

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3	(i) 3 Y	M1 A1 [2]	For 3 (allow -3) For Y (cao)																							
	(ii) 5 > 3, -2 > -4, 5 > -1 and 6 > 0 or using signs of differences +2, +2, +6, +6 3 > -2, -5 > -6, 1 > 0, 4 > 2 or equivalent, or using differences Reduced matrix: <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td></td> <td colspan="3" style="text-align: center;">Colin's strategy</td> </tr> <tr> <td></td> <td></td> <td style="border-right: 1px solid black;">W</td> <td style="border-right: 1px solid black;">X</td> <td>Y</td> </tr> <tr> <td rowspan="3" style="vertical-align: middle;">Rose's strategy</td> <td style="border-right: 1px solid black;">A</td> <td style="border-right: 1px solid black;">-1</td> <td style="border-right: 1px solid black;">4</td> <td>-3</td> </tr> <tr> <td style="border-right: 1px solid black;">B</td> <td style="border-right: 1px solid black;">5</td> <td style="border-right: 1px solid black;">-2</td> <td>5</td> </tr> <tr> <td style="border-right: 1px solid black;">D</td> <td style="border-right: 1px solid black;">-5</td> <td style="border-right: 1px solid black;">6</td> <td>-4</td> </tr> </table>			Colin's strategy					W	X	Y	Rose's strategy	A	-1	4	-3	B	5	-2	5	D	-5	6	-4	M1 A1 M1 A1 B1 [5]	For an appropriate comparison, or implied For all four comparisons seen For an appropriate comparison, or implied For all four comparisons seen For correct reduced matrix, with rows and columns labelled A, B, D and W, X, Y Cao
		Colin's strategy																								
		W	X	Y																						
Rose's strategy	A	-1	4	-3																						
	B	5	-2	5																						
	D	-5	6	-4																						
	(iii) Row minima are -3, -2, -5 Play-safe for Rose is B Column maxima are 5, 6, 5 Play-safes for Colin are W and Y Not stable	M1 M1 A1 [3]	Follow through their 3x3 reduced matrix For identifying row B For identifying columns W and Y For 'no' or 'not stable'																							
	(iv) 5 is added throughout the matrix to make the entries non-negative. In this augmented reduced matrix, $9p_1 + 3p_2 + 11p_3$ is the expected number of points won by Rose when Colin plays strategy X	M1 A1 [2]	For 'add 5' or equivalent For identifying that this is when Colin plays strategy X																							
	(v) $p_1 = \frac{7}{48}, p_2 = \frac{27}{48}, p_3 = \frac{14}{48}$ $\Rightarrow m \leq \frac{298}{48}$ (or $6\frac{5}{24}, 6.2083, 6.21$) in all three cases $\Rightarrow M = \frac{58}{48}$ (or $\frac{29}{24}, 1\frac{5}{24}, 1.2083, 1.21$)	M1 A1 [2]	For attempting to evaluate m cao (in any appropriate form)																							

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4 (i)

Activity	Duration	Immediate predecessors
A	6	-
B	4	-
C	5	A
D	1	A, B
E	5	A, D
F	4	D
G	2	C, E, F

B1

ANSWERED ON INSERT

For predecessors for activities A, B and C correct

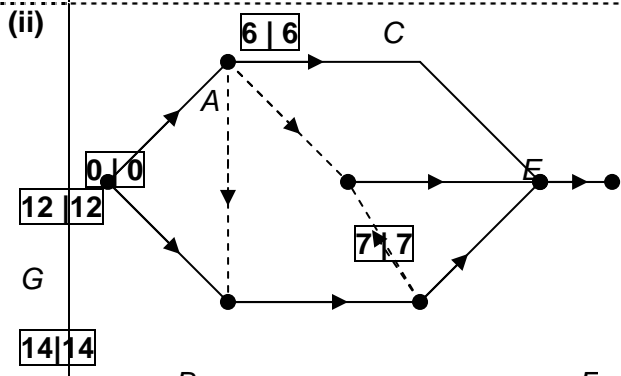
B1

For predecessors for activities D, F and G correct

B1

[3]

For predecessors for activity E correct



M1

For carrying out forward pass (no more than one independent error)

A1

For all early event times correct

M1

For carrying out backwards pass (no more than one independent error)

A1

For all late event times correct

Minimum completion time = 14 hours
Critical activities: A, D, E, G

B1

For 14 cao

B1

For A, D, E, G only cao

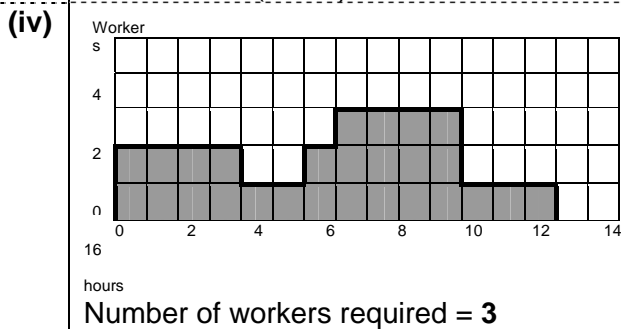
[6]

(iii) Increased by 2 (hours)
Becomes 16 (hours)

B1

For stating that time increases by 2, or equivalent

[1]



B1

For a resource histogram with no overhanging cells

M1

For a reasonable attempt, fit their start times if possible

A1

For a completely correct histogram (cao)

B1

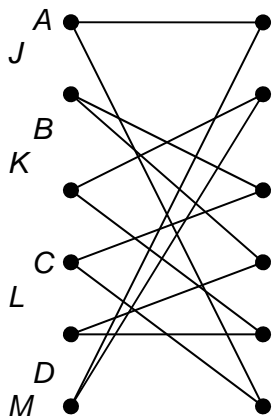
For 3 or follow through their histogram if possible

[4]

14

5

(i)



M1

ANSWERED ON INSERT

For a substantially correct attempt

A1
[2]

For a completely correct bipartite graph

(ii)

$C-N \quad E-M \quad F-K$
 $A-J \quad B-L \quad D-O$

M1

For pairing $F-K, C-N, E-M$

A1
[2]

For all correct (Diagram only \Rightarrow M1, A0)

(iii)

	J	K	L	M	N	O
A	2	5	2	2	5	2
B	2	5	2	0	5	5
C	5	0	5	5	2	2
D	2	5	0	5	5	2
E	5	2	5	2	0	5
F	2	2	5	5	2	2

B1

For '5' in all the entries that should be 5

B1

For '2' in all the entries that should be 2

B1

For '0' in all the entries that should be 0

[3]

(iv)

Reduce rows

0	3	0	0	3	0
2	5	2	0	5	5
5	0	5	5	2	2
2	5	0	5	5	2
5	2	5	2	0	5
0	0	3	3	0	0

Columns are already reduced

Or, reduce columns

0	5	2	2	5	0
0	5	2	0	5	3
3	0	5	5	2	0
0	5	0	5	5	0
3	2	5	2	0	3
0	2	5	5	2	0

Rows are already reduced

Cannot cross out 0's using fewer than 6 lines so matching is complete

$A-J \quad B-M \quad C-K \quad D-L \quad E-N$
 $F-O$
 $A-O \quad B-M \quad C-K \quad D-L \quad E-N$
 $F-J$

First matching: Fred and Jenny
Second matching: Jenny and Olivia

M1

For a substantially correct attempt from their matrix

A1

For a correct reduction of rows and columns (or columns and rows) for their matrix

M1

For achieving a reduced cost matrix with a complete matching of zero cost (without unnecessary augmenting)

A1

0's in correct cells (not ft)

B1

For this matching or ft their reduced cost matrix

B1

For this matching or ft their reduced cost matrix

B1

B1

[8]

For the names for their first matching
For the names for their second matching

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