

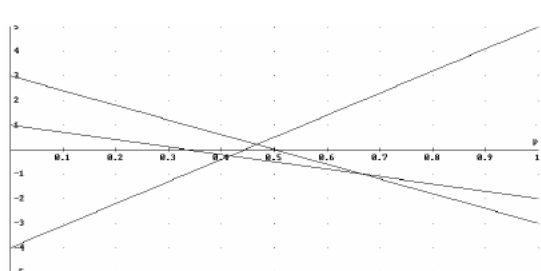
# Mark Scheme 4737

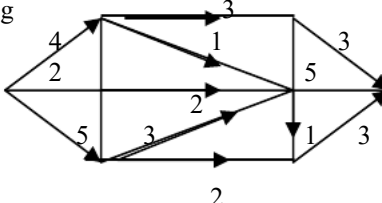
## January 2007

1	(i)	The Hungarian algorithm finds the minimum cost allocation, we need to subtract each score from 6 to convert a maximisation into a minimisation.	B1	A valid reference to maximising/minimising	[1]																										
	(ii)	First subtract each entry from 6																													
			<table border="1"> <thead> <tr> <th></th> <th>Attic</th> <th>Back</th> <th>Down</th> <th>Front</th> </tr> </thead> <tbody> <tr> <td>Phil</td> <td>1</td> <td>5</td> <td>6</td> <td>2</td> </tr> <tr> <td>Rob</td> <td>5</td> <td>0</td> <td>5</td> <td>4</td> </tr> <tr> <td>Sam</td> <td>2</td> <td>4</td> <td>4</td> <td>3</td> </tr> <tr> <td>Tim</td> <td>3</td> <td>1</td> <td>6</td> <td>6</td> </tr> </tbody> </table>		Attic	Back	Down	Front	Phil	1	5	6	2	Rob	5	0	5	4	Sam	2	4	4	3	Tim	3	1	6	6	B1	Correctly subtracting each entry from 6 (cao)	
			Attic	Back	Down	Front																									
		Phil	1	5	6	2																									
Rob	5	0	5	4																											
Sam	2	4	4	3																											
Tim	3	1	6	6																											
Reduce rows																															
	<table border="1"> <tbody> <tr> <td>0</td> <td>4</td> <td>5</td> <td>1</td> </tr> <tr> <td>5</td> <td>0</td> <td>5</td> <td>4</td> </tr> <tr> <td>0</td> <td>2</td> <td>2</td> <td>1</td> </tr> <tr> <td>2</td> <td>0</td> <td>5</td> <td>5</td> </tr> </tbody> </table>	0	4	5	1	5	0	5	4	0	2	2	1	2	0	5	5	M1	Reducing rows first												
0	4	5	1																												
5	0	5	4																												
0	2	2	1																												
2	0	5	5																												
Then reduce columns																															
	<table border="1"> <tbody> <tr> <td>0</td> <td>4</td> <td>3</td> <td>0</td> </tr> <tr> <td>5</td> <td>0</td> <td>3</td> <td>3</td> </tr> <tr> <td>0</td> <td>2</td> <td>0</td> <td>0</td> </tr> <tr> <td>2</td> <td>0</td> <td>3</td> <td>4</td> </tr> </tbody> </table>	0	4	3	0	5	0	3	3	0	2	0	0	2	0	3	4	M1 dep	Then reducing columns												
0	4	3	0																												
5	0	3	3																												
0	2	0	0																												
2	0	3	4																												
Cover 0's using 3 lines																															
	<table border="1"> <tbody> <tr> <td>0</td> <td>4</td> <td>3</td> <td>0</td> </tr> <tr> <td>5</td> <td>0</td> <td>3</td> <td>3</td> </tr> <tr> <td>0</td> <td>2</td> <td>0</td> <td>0</td> </tr> <tr> <td>2</td> <td>0</td> <td>3</td> <td>4</td> </tr> </tbody> </table>	0	4	3	0	5	0	3	3	0	2	0	0	2	0	3	4	A1	A correct reduced cost matrix from rows reduced first (cao)												
0	4	3	0																												
5	0	3	3																												
0	2	0	0																												
2	0	3	4																												
Augment by 2																															
	<table border="1"> <tbody> <tr> <td>0</td> <td>6</td> <td>3</td> <td>0</td> </tr> <tr> <td>3</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>0</td> <td>4</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>2</td> </tr> </tbody> </table>	0	6	3	0	3	0	1	1	0	4	0	0	0	0	1	2	M1	Covering zeros using minimum number of lines and augmenting by (their) 2												
0	6	3	0																												
3	0	1	1																												
0	4	0	0																												
0	0	1	2																												
	<table border="1"> <tbody> <tr> <td>0</td> <td>6</td> <td>3</td> <td>0</td> </tr> <tr> <td>3</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>0</td> <td>4</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>2</td> </tr> </tbody> </table>	0	6	3	0	3	0	1	1	0	4	0	0	0	0	1	2	A1	A correct augmented matrix (cao) from rows reduced first												
0	6	3	0																												
3	0	1	1																												
0	4	0	0																												
0	0	1	2																												
	Phil = Front room Rob = Back room Sam = Downstairs room Tim = Attic room																														
		B1	Correct matching	[7]																											
<b>Total = 8</b>																															

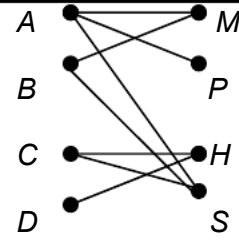
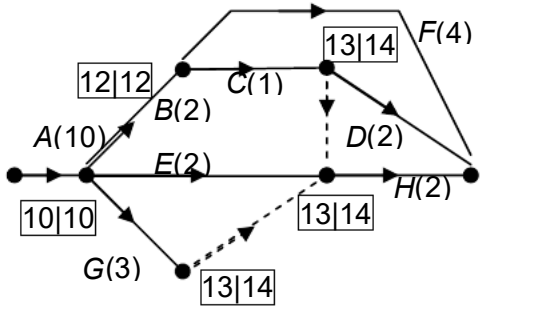
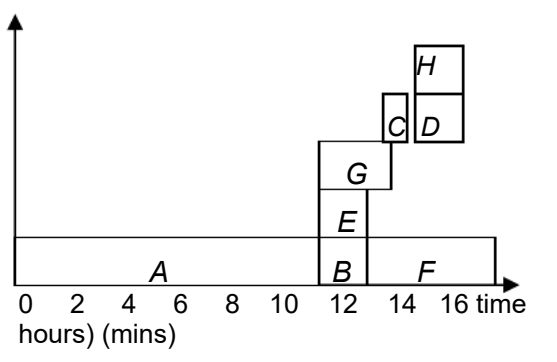
2	(i)	16 hours <i>A, B, D, F</i>	B1	16 with units	[2]
			B1	All four critical activities and no others	[2]
	(ii)		M1	A reasonable attempt at a resource histogram	
		A1	An entirely correct graph with scales and labels	[2]	
	(iii)	Start <i>C</i> at time 3 Start <i>E</i> at time 8 Start <i>G</i> at time 16 Complete in 19 hours	B1 B1 B1 B1	' <i>C</i> ' and '3' or 'after <i>A</i> ' or 'with <i>B</i> ' ' <i>E</i> ' and '8' or 'after <i>B</i> ' or 'with <i>D</i> ' ' <i>G</i> ' and '16' or 'after <i>F</i> ' 19	[4]
<b>Total = 8</b>					

3	(i)	-5	B1	-5	
	(ii)	Because $-3 < 2$ in column $Y$ and $2 > -2$ in row $Y$	M1 A1	Either of these, possibly with others Both of these comparisons and no others	[2]
	(iii)	Play-safe for Rebecca is $Z$ Play-safe for Claire is $Y$ Best choice is $X$	B1 B1 B1 ft	Indicating row $Z$ Indicating column $Y$ The correct choice with their play-safe	[3]
	(iv)	For Rebecca, $-1 >$ smaller of $\{-3, \text{value that } 5 \text{ becomes}\}$ For Claire, $2 <$ larger of $\{3, \text{value that } 5 \text{ becomes}\}$	B1  B1	This, or equivalent, or 5 is not in the play-safe row  This, or equivalent (but NOT '5 is not in the play-safe column')	[2]
<b>Total = 8</b>					

4	(i)	$5p - 4(1-p)$ $= 9p - 4$	M1 A1	This, or implied $9p - 4$ or $-4 + 9p$	[2]
	(ii)		M1 A1 A1 A1	Correct structure to graph Line $E = 9p - 4$ plotted from (0,-4) to (1, 5) Line $E = 3 - 6p$ plotted from (0, 3) to (1,-3) Line $E = 1 - 3p$ plotted from (0, 1) to (1,-2)  Withhold an A1 for horizontal scale beyond 0 to 1	[4]
	(iii)	$9p - 4 = 1 - 3p$ $\Rightarrow p = 5/12$ or 0.41 to 0.42 (or better)	M1 A1 ft	Solving the correct pair of lines for their graph Correct value for their lines	[2]
	(iv)	If Colin plays $X$ or $Z$ , Rowan's expected winnings are $-0.25$ so Colin's expected winnings are $+0.25$  Even if Colin plays optimally he cannot expect, in the long run, to do better on average than to win what Rowan loses.	B1  B1	Showing why it is $+0.25$ for Colin  Realising that Colin need to play his optimal strategy as well as Rowan	[2]
<b>Total = 10</b>					

5	(i)	4+2+4+0+5 = 15	M1 A1	At least four correct terms 15 from correct calculation	[2]
	(ii)	Subtract 3 from SA, AD, DT and add 3 to TD, DA, AS Subtract 2 from SB, BE, ET and add 2 to TE, EB, BS Subtract 2 from SC, CF, FT and add 2 to TF, FC, CS	M1	Correctly subtracting along one of the three flow augmenting routes	[3]
			M1	Correctly adding along one of the three flow augmenting routes	
			A1	All changes correct and no other changes made	
	(iii)	eg Route SCET Flow = 3	B1 B1 ft	Any valid flow augmenting route (not ft) Maximum extra flow on their route	[2]
(iv)	Maximum flow = 11 litres per second Cut: X = {S}, Y = {A,B,C,D,E,F,T}	B1 B1	11 with units This cut described in this way	[2]	
(v)	eg 	M1 M1 A1	At each vertex, flow in = flow out On each arc, flow ≤ capacity A valid directed flow of 11	[3]	
<b>Total = 12</b>					

6	(i)	<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="2">1</td> <td>0</td> <td>0</td> <td>4</td> <td>4</td> </tr> <tr> <td>1</td> <td>0</td> <td>3</td> <td>3</td> </tr> <tr> <td rowspan="6">2</td> <td rowspan="2">0</td> <td>0</td> <td>min(6, 4) = 4</td> <td rowspan="2">4</td> </tr> <tr> <td>1</td> <td>min(2, 3) = 2</td> </tr> <tr> <td rowspan="2">1</td> <td>0</td> <td>min(2, 4) = 2</td> <td rowspan="2">3</td> </tr> <tr> <td>1</td> <td>min(4, 3) = 3</td> </tr> <tr> <td rowspan="2">2</td> <td>0</td> <td>min(2, 4) = 2</td> <td rowspan="2">3</td> </tr> <tr> <td>1</td> <td>min(3, 3) = 3</td> </tr> <tr> <td rowspan="3">3</td> <td rowspan="3">0</td> <td>0</td> <td>min(5, 4) = 4</td> <td rowspan="3">4</td> </tr> <tr> <td>1</td> <td>min(5, 3) = 3</td> </tr> <tr> <td>2</td> <td>min(2, 3) = 2</td> </tr> </tbody> </table>	Stage	State	Action	Working	Maximin	1	0	0	4	4	1	0	3	3	2	0	0	min(6, 4) = 4	4	1	min(2, 3) = 2	1	0	min(2, 4) = 2	3	1	min(4, 3) = 3	2	0	min(2, 4) = 2	3	1	min(3, 3) = 3	3	0	0	min(5, 4) = 4	4	1	min(5, 3) = 3	2	min(2, 3) = 2	B1 M1 A1 M1 A1 B1 ft M1 ft A1 ft	Maximin value correct for (2;0) Completing working column of (2;1) Maximin value correct for (2;1) Completing working column for (2;2) Maximin value correct for (2;2) Transferring maximin values from stage 2 Completing working column for stage 3 Maximin value correct for stage 3	[8]
		Stage	State	Action	Working	Maximin																																									
1	0	0	4	4																																											
	1	0	3	3																																											
2	0	0	min(6, 4) = 4	4																																											
		1	min(2, 3) = 2																																												
	1	0	min(2, 4) = 2	3																																											
		1	min(4, 3) = 3																																												
	2	0	min(2, 4) = 2	3																																											
		1	min(3, 3) = 3																																												
3	0	0	min(5, 4) = 4	4																																											
		1	min(5, 3) = 3																																												
		2	min(2, 3) = 2																																												
(ii)	4  (3;0) – (2;0) – (1;0) – (0;0) (or in reverse)	B1 ft M1 ft M1 ft A1	4, or ft their table if possible (3;0) – (2;0), or ft their table if possible (2;0) – (1;0), or ft their table if possible For maximin route correct	[4]																																											
<b>Total = 12</b>																																															

7	(i)	 <p>Alternating path: <math>D - H - C - S - B - M - A - P</math></p> <p>Matching: <math>A - P</math> <math>B - M</math> <math>C - S</math> <math>D - H</math></p>	B1  B1  B1	<p>Correct bipartite graph seen Ignore further working on graph for incomplete matching or alternating path</p> <p>This, or in reverse, listed (not just deduced from labelling of diagram)</p> <p>This matching</p>	[3]
	(ii)		M1 A1  M1 A1 ft  M1 A1 ft	<p>Precedences correct A correct network (directions may be implied)</p> <p>Forwards pass Early event times correct (need not use boxes)</p> <p>Backwards pass Late event times (need not use boxes)</p>	[6]
	(iii)	<p>Completion time: 16 hours Critical activities: <math>A B F</math></p>	B1 B1	<p>16 with units Correct list</p>	[2]
	(iv)		M1  A1 ft  A1 ft	<p>Accept any variation of cascade chart</p> <p>Structure of chart correct, activities may be collected together or on individual rows</p> <p>Non-critical activities correct, none split across rows (floats not necessary)</p> <p>Critical activities correct</p>	[3]
<b>Total = 14</b>					