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

	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)

Reduce rows

0	4	5	1
5	0	5	4
0	2	2	1
2	0	5	5

M1 — Reducing rows first

Then reduce columns

0	4	3	0
5	0	3	3
0	2	0	0
2	0	3	4

M1 dep — Then reducing columns

A1 — A correct reduced cost matrix from rows reduced first (cao)

Cover 0's using 3 lines

0	4	3	0
5	0	3	3
0	2	0	0
2	0	3	4

M1 — Covering zeros using minimum number of lines and augmenting by (their) 2

Augment by 2

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

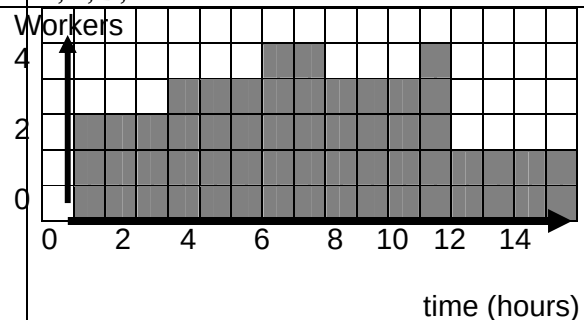
Phil = Front room
Rob = Back room
Sam = Downstairs room
Tim = Attic room

B1 — Correct matching — [7]

Total = 8

2 **(i)** 16 hours — B1 — 16 with units
A, B, D, F — B1 — All four critical activities and no others — [2]

(ii)



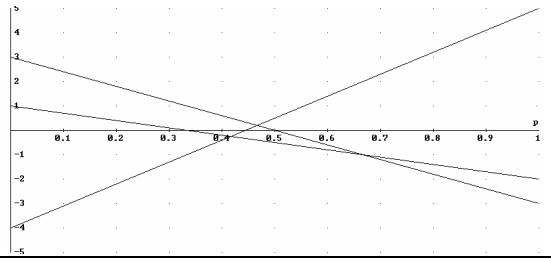
M1 — A reasonable attempt at a resource histogram

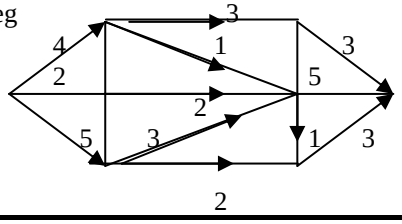
A1 — An entirely correct graph with scales and labels — [2]

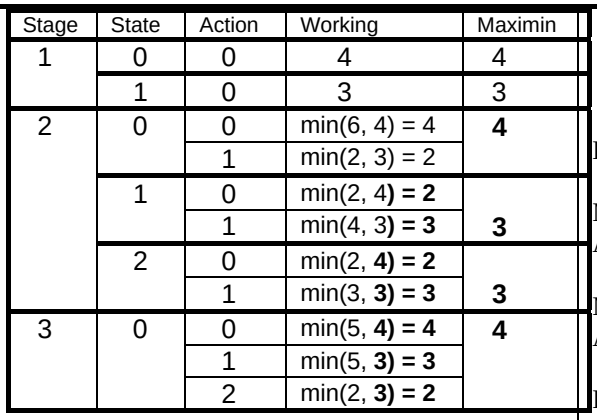
(iii)
Start *C* at time 3 — B1 — '*C*' and '3' or 'after *A*' or 'with *B*'
Start *E* at time 8 — B1 — '*E*' and '8' or 'after *B*' or 'with *D*'
Start *G* at time 16 — B1 — '*G*' and '16' or 'after *F*'
Complete in 19 hours — B1 — 19 — [4]

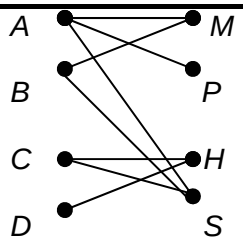
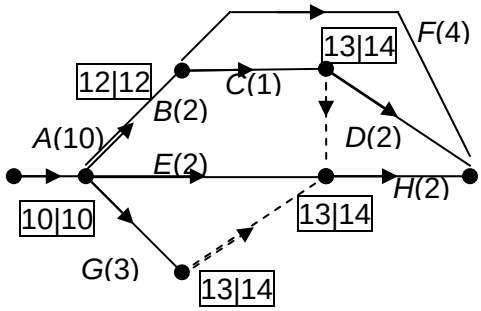
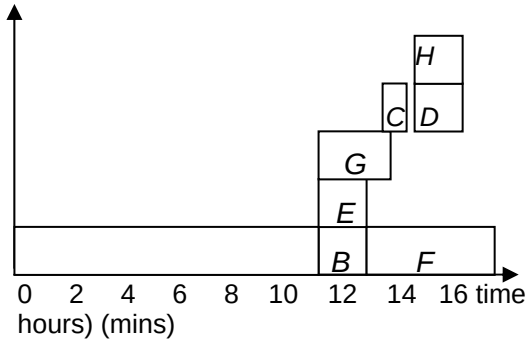
Total = 8

3	**(i)**	-5	B1	-5	[1]
	(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, value that 5 becomes} For Claire, 2 < larger of {3, value that 5 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]
				Total =	**8**

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]
				Total =	**10**

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 M1 A1	Correctly subtracting along one of the three flow augmenting routes Correctly adding along one of the three flow augmenting routes All changes correct and no other changes made	[3]
	(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 $\leq$ capacity A valid directed flow of 11	[3]
					Total = 12

6	**(i)**				
			B1	Maximin value correct for (2;0)	
			M1 A1	Completing working column of (2;1) Maximin value correct for (2;1)	
			M1 A1	Completing working column for (2;2) Maximin value correct for (2;2)	
			B1 ft M1 ft A1 ft	Transferring maximin values from stage 2 Completing working column for stage 3 Maximin value correct for stage 3	[8]
	(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]
					Total = 12

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