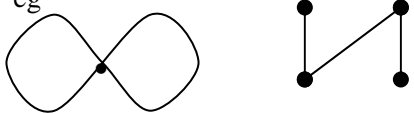
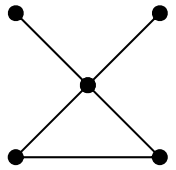
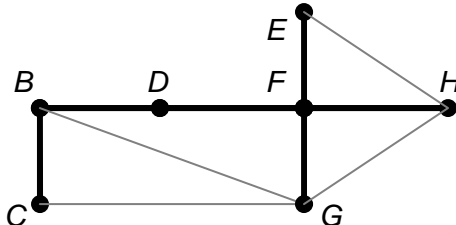


4736 Decision Mathematics 1

1 (i)	[43 172 536 17 314 462 220 231] 43 172 536 17 220 314 462 231	M1 M1 A1	First folder correct Second folder correct All correct (cao)	[3]
(ii)	536 462 314 231 220 172 43 17 536 462 314 231 220 172 43 17	B1 M1 A1	List sorted into decreasing order seen (cao) [Follow through from a decreasing list with no more than 1 error or omission] First folder correct All correct	[3]
(iii)	$(5000 \div 500)^2 \times 1.3$ $= 130$ seconds	M1 A1	$10^2 \times 1.3$ or any equivalent calculation Correct answer, with units	[2]
Total = 8				

2 (i)	The sum of the orders must be even, (but $1+2+3+3 = 9$ which is odd).	B1	There must be an even number of odd nodes.	[1]
(ii) a	eg 	M1 A1	A graph with five vertices that is neither connected nor simple Vertex orders 1, 1, 2, 2, 4	[2]
b	Because it is not connected	B1	You cannot get from one part of the graph to the other part.	[1]
c	eg 	B1	A connected graph with vertex orders 1, 1, 2, 2, 4 (Need not be simple)	[1]
(iii) a	There are five arcs joined to A. Either Ann has met (at least) three of the others or she has met two or fewer, in which case there are at least three that she has not met. In the first case at least three of the arcs joined to A are blue, in the second case at least three of the arcs joined to A are red.	M1 A1	A reasonable attempt (for example, identifying that there are five arcs joined to A) A convincing explanation (this could be a list of the possibilities or a well reasoned explanation)	[2]
b	If any two of Bob, Caz and Del have met one another then B, C and D form a blue triangle with A. Otherwise B, C and D form a red triangle.	M1 A1	A reasonable or partial attempt (using A with B, C, D) A convincing explanation (explaining both cases fully)	[2]
Total = 9				

3 (i)	$y \geq x$ $x + y \leq 8$ $x \geq 1$	M1 M1 M1 A1	Line $y = x$ in any form Line $x + y = 8$ in any form Line $x = 1$ in any form All inequalities correct [Ignore extra inequalities that do not affect the feasible region]	[4]
(ii)	(1, 1), (1, 7), (4, 4)	M1 A1	Any two correct coordinates All three correct [Extra coordinates given \Rightarrow M1, A0]	[2]
(iii)	(1, 7) 23 (4, 4) 20 At optimum, $x = 1$ and $y = 7$ Maximum value = 23	M1 A1 A1	Follow through if possible Testing vertices or using a line of constant profit (may be implied) Accept (1, 7) identified 23 identified	[3]
(iv)	$2 \times 1 + k \times 7 \geq 2 \times 4 + k \times 4$ $k \geq 2$	M1 A1	$2 + 7k$ or implied, or using line of gradient $-\frac{2}{k}$ Greater than or equal to 2 (cao) [$k > 2 \Rightarrow$ M1, A0]	[2]
Total = 11				

4 (i)	<div><div><table><tr><td>1</td><td>0</td></tr><tr><td colspan="2"></td></tr></table><p>A</p></div><div><table><tr><td>6</td><td>8</td></tr><tr><td colspan="2">8</td></tr></table><p>E</p></div></div> <div><table><tr><td>2</td><td>2</td><td>4</td><td>5</td><td>5</td><td>6.5</td><td>7</td><td>9.5</td></tr><tr><td colspan="2">2</td><td colspan="2">6 5</td><td colspan="2">6.5</td><td colspan="2">9.5</td></tr></table><p>B D F H</p></div> <div><table><tr><td>3</td><td>4.5</td></tr><tr><td colspan="2">4.5</td></tr></table><p>C</p></div> <div><table><tr><td colspan="2"></td><td colspan="2"></td></tr><tr><td>14</td><td>13.5</td><td colspan="2">10.5</td></tr></table><p>G</p></div> <p>Route = A – B – D – F – H Length = 9.5 miles</p>	1	0			6	8	8		2	2	4	5	5	6.5	7	9.5	2		6 5		6.5		9.5		3	4.5	4.5						14	13.5	10.5		M1 M1 A1 B1 B1 B1 B1	Both 6 and 5 shown at <i>D</i> [5 may appear as perm label only] 14, 13.5 and 10.5 shown at <i>G</i> No extra temporary labels All temporary labels correct [condone perm values only appearing as perm labels] [Dep on both M marks] All permanent labels correct [may omit <i>G</i> , but if given it must be correct] Order of labelling correct [may omit <i>G</i> but if given it must be correct] cao cao	[7]
1	0																																							
6	8																																							
8																																								
2	2	4	5	5	6.5	7	9.5																																	
2		6 5		6.5		9.5																																		
3	4.5																																							
4.5																																								
14	13.5	10.5																																						
(ii)	Route Inspection problem	B1	Accept Chinese Postman	[1]																																				
(iii)	Odd nodes: <i>A, D, E</i> and <i>H</i> $AD = 5$ $AE = 8$ $AH = 9.5$ $EH = \frac{5}{10}$ $DH = \frac{4.5}{12.5}$ $DE = \frac{3.5}{13.0}$ Repeat <i>AD</i> (<i>A-B-D</i>) and <i>EH</i> (<i>E-F-H</i>) Length = 67.5 + 10 = 77.5 miles	B1 M1 A1 M1 A1	Identifying or using <i>A, D, E, H</i> Attempting at least one pairing At least one correct pairing or correct total Adding their 10 to 67.5 77.5 (cao)	[5]																																				
(iv)	Repeat arcs <i>EF</i> and <i>FD</i> $3.5 + 67.5 = 71$ miles	B1 B1	cao [NOT <i>DE</i> or <i>D-F-E</i>] cao	[2]																																				
(v)	<i>A – B – C – G – F – D</i> then method stalls <i>E</i> and <i>H</i> are missed out	B1	Showing route as far as <i>D</i> and then explaining the problem	[1]																																				
(vi)	<i>C – B – A – D – F – E – H – G – C</i> 37.5 miles	M1 A1 B1	[If final <i>C</i> is missing \Rightarrow M1, A0] [A diagram needs arrows for A1] 37.5 (cao)	[3]																																				
(vii)	<div></div> <p>Nodes: <i>B C D F E H G</i> Weight = 16 miles [Two shortest arcs from <i>A</i> are <i>AB</i> and <i>AD</i>] $2 + 6 + 16$ Lower bound = 24 miles</p>	M1 A1 B1 B1 M1 A1	A spanning tree on reduced network (may show <i>AB, AD</i>) Correct minimum spanning tree marked, with no extra arcs cao cao 8 + their 16 (or implied) cao	[6]																																				
Total = 25																																								

5 (i)	15x+15y+30z ≤ 9000 [divide through by 15 to get x+y+2z ≤ 600 as given] Stamping out: 5x+8y+10z ≤ 3600 Fixing pin: 50x+50y+50z ≤ 25000 x + y + z ≤ 500 Checking: 100x+50y+20z ≤ 10000 10x+5y+2z ≤ 1000	B1	15x+15y+30z ≤ 9000	[4]																																																						
		B1	5x+8y+10z ≤ 3600																																																							
		B1	x + y + z ≤ 500																																																							
		B1	10x+5y+2z ≤ 1000																																																							
(ii)	x, y and z are non-negative	B1	x ≥ 0, y ≥ 0 and z ≥ 0	[1]																																																						
(iii)	(P =) 4x + 3y + z	B1	cao	[1]																																																						
(iv)	<table><tr><td>P</td><td>x</td><td>y</td><td>z</td><td>s</td><td>t</td><td>u</td><td>v</td><td>RHS</td></tr><tr><td>1</td><td>-4</td><td>-3</td><td>-1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>2</td><td>1</td><td>0</td><td>0</td><td>0</td><td>600</td></tr><tr><td>0</td><td>5</td><td>8</td><td>10</td><td>0</td><td>1</td><td>0</td><td>0</td><td>3600</td></tr><tr><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>500</td></tr><tr><td>0</td><td>10</td><td>5</td><td>2</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1000</td></tr></table>	P	x	y	z	s	t	u	v	RHS	1	-4	-3	-1	0	0	0	0	0	0	1	1	2	1	0	0	0	600	0	5	8	10	0	1	0	0	3600	0	1	1	1	0	0	1	0	500	0	10	5	2	0	0	0	1	1000	B1 B1 M1 A1	Follow through if reasonable -4 -3 -1 in objective row Correct use of slack variables 1 1 2 and 600 correct All constraint rows correct Accept variations in order of rows and columns	[4]
	P	x	y	z	s	t	u	v	RHS																																																	
	1	-4	-3	-1	0	0	0	0	0																																																	
	0	1	1	2	1	0	0	0	600																																																	
	0	5	8	10	0	1	0	0	3600																																																	
	0	1	1	1	0	0	1	0	500																																																	
0	10	5	2	0	0	0	1	1000																																																		
(v)	Pivot on the 10 in the x-column	B1	Correct choice of pivot from x- column	[3]																																																						
	<table><tr><td>1</td><td>0</td><td>-1</td><td>-0.2</td><td>0</td><td>0</td><td>0</td><td>0.4</td><td>400</td></tr><tr><td>0</td><td>0</td><td>0.5</td><td>1.8</td><td>1</td><td>0</td><td>0</td><td>-0.1</td><td>500</td></tr><tr><td>0</td><td>0</td><td>5.5</td><td>9</td><td>0</td><td>1</td><td>0</td><td>-0.5</td><td>3100</td></tr><tr><td>0</td><td>0</td><td>0.5</td><td>0.8</td><td>0</td><td>0</td><td>1</td><td>-0.1</td><td>400</td></tr><tr><td>0</td><td>1</td><td>0.5</td><td>0.2</td><td>0</td><td>0</td><td>0</td><td>0.1</td><td>100</td></tr></table>	1	0		-1	-0.2	0	0	0	0.4	400	0	0	0.5	1.8	1	0	0	-0.1	500	0	0	5.5	9	0	1	0	-0.5	3100	0	0	0.5	0.8	0	0	1	-0.1	400	0	1	0.5	0.2	0	0	0	0.1	100	M1 A1	[Follow through their tableau and valid pivot if possible: no negative values in RHS column and P value has not decreased] Pivot row correct Other rows correct									
	1	0	-1		-0.2	0	0	0	0.4	400																																																
	0	0	0.5		1.8	1	0	0	-0.1	500																																																
	0	0	5.5		9	0	1	0	-0.5	3100																																																
	0	0	0.5		0.8	0	0	1	-0.1	400																																																
	0	1	0.5		0.2	0	0	0	0.1	100																																																
	Pivot on 0.5 in the last row of y-column	B1	Correct choice of pivot from y-column		[3]																																																					
	<table><tr><td>1</td><td>2</td><td>0</td><td>0.2</td><td>0</td><td>0</td><td>0</td><td>0.6</td><td>600</td></tr><tr><td>0</td><td>-1</td><td>0</td><td>1.6</td><td>1</td><td>0</td><td>0</td><td>-0.2</td><td>400</td></tr><tr><td>0</td><td>-11</td><td>0</td><td>6.8</td><td>0</td><td>1</td><td>0</td><td>-1.6</td><td>2000</td></tr><tr><td>0</td><td>-1</td><td>0</td><td>0.6</td><td>0</td><td>0</td><td>1</td><td>-0.2</td><td>300</td></tr><tr><td>0</td><td>2</td><td>1</td><td>0.4</td><td>0</td><td>0</td><td>0</td><td>0.2</td><td>200</td></tr></table>	1	2			0	0.2	0	0	0	0.6	600	0	-1	0	1.6	1	0	0	-0.2	400	0	-11	0	6.8	0	1	0	-1.6	2000	0	-1	0	0.6	0	0	1	-0.2	300	0	2	1	0.4	0	0	0	0.2	200	M1 A1	[Follow through their tableau and valid pivot if possible] Pivot row correct Other rows correct								
	1	2	0			0.2	0	0	0	0.6	600																																															
	0	-1	0	1.6		1	0	0	-0.2	400																																																
	0	-11	0	6.8		0	1	0	-1.6	2000																																																
	0	-1	0	0.6	0	0	1	-0.2	300																																																	
	0	2	1	0.4	0	0	0	0.2	200																																																	
	x = 0, y = 200, z = 0, P = 600 Make 20000 metallic badges (and no laminated badges or plastic badges)	B1	Interpretation of their x, y and z values in context (may imply zero entries)	[3]																																																						
	To give a profit of £600	B1	Interpretation of their P value in context																																																							
	6000 seconds (100 min) of printing time not used, 2000 seconds (33 min 20 sec) of stamping out time not used, 15000 seconds (250 min) of fixing pin time not used. All the checking time is used	B1	Interpretation of their slack variable values																																																							
	Total = 19																																																									