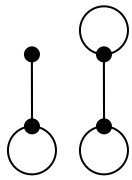
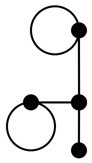
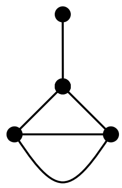
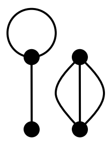
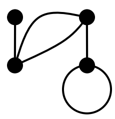
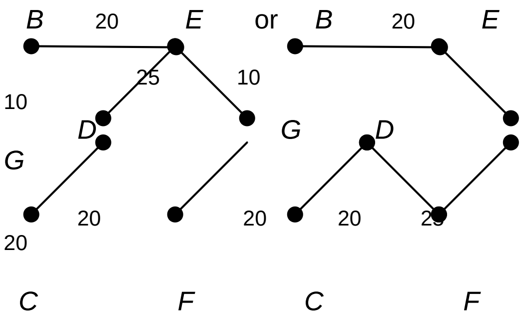
Mark Scheme 4736
June 2006

1	**(i)**	2 4 3 3 2 5 4 Box 1 **2 4 2** Box 2 **3 3** Box 3 **5** Box 4 **4**	M1 A1 [2]	For packing these seven weights into boxes with no more than 8 kg total in each box For this packing
	(ii)	5 4 4 3 3 2 2 Box 1 **5 3** Box 2 **4 4** Box 3 **3 2 2**	B1 M1 A1 [3]	For putting the weights into decreasing order (may be implied from packing) For packing the seven weights into three boxes with no more than 8 kg total in each box For this packing
	(iii)	15×2^2 = **60** seconds	M1 A1 [2]	For a correct calculation For 60 or 60 seconds or 1 minute $\boxed{7}$
2	**(i)**	 graph *A*  graph *B*  graph *C* other solutions:  or 	M1 A1 [2] --------- M1 A1 [2] --------- M1 A1 [2]	Graphs may be in any order For a reasonable attempt For a graph that is topologically equivalent to one of these graphs For a different reasonable attempt For a graph that is topologically equivalent to one of these graphs For another different reasonable attempt For a graph that is topologically equivalent to one of these graphs
	(ii)	The graphs each have four **odd** nodes, but Eulerian graphs have no odd nodes.	B1 [1]	For any recognition that the nodes are not all even $\boxed{7}$

3	(i)	**Travelling salesperson**	B1 [1]	Identifying TSP by name
	(ii)	***A – B – E – G – F – D – C – A*** 130 (minutes) Shortest possible time **$\leq$ 130 minutes**	M1 A1 B1 B1 [4]	For starting with *A – B – E – G - …* For this closed tour For 130 For less than or equal to their time, **with units**
	(iii)	Order of connecting: ***B***, ***E***, ***G***, ***F***, ***D***, ***C***  Lower bound = 10 + 15 + 95 = **120 minutes**	B1 M1 A1 M1 M1 A1 [6]	For a valid vertex order (or arc order) for their starting point For a diagram or listing showing a tree connecting the vertices *B*, *C*, *D*, *E*, *F* and *G* but not *A* For a diagram showing one of these trees (vertices must be labelled but arc weights are not needed) For stating or using the total weight of their tree For stating or using *AB* and *AD* or 10 + 15 For 120 or calculating 25 + their 95, **with units**
	(iv)	***A – B – E – G – F – C – D – A*** or this in reverse	M1 A1 [2]	For a reasonable attempt For a valid tour of weight 125 $\boxed{13}$

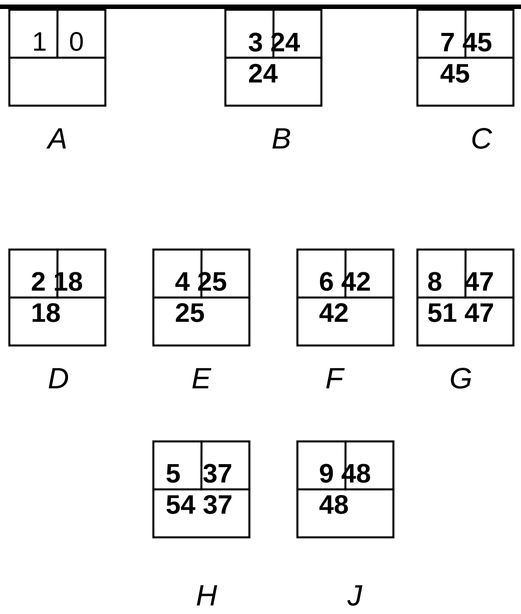
4	**(i)**	**$x \le 2$** **$y \ge 1$** **$y \le 2x$** **$x + y \le 4$**	B1 B1 B1 B1 [4]	Strict inequalities used, penalise first time only All inequalities reversed, penalise first time only
	(ii)	**(2, 1), (2, 2)** **(½, 1)** **$(1\frac{1}{3}, 2\frac{2}{3})$**	B1 B1 B1 [3]	Both of these This vertex in any exact form This vertex in any exact form or correct to 3 sf
	(iii)	x y $P = x + 2y$ 2 1 4 2 2 6 ½ 1 2½ $1\frac{1}{3}$ $2\frac{2}{3}$ $6\frac{2}{3}$ $x = 1\frac{1}{3}$, $y = 2\frac{2}{3}$ (may be given in coordinate form) $P = 6\frac{2}{3}$	M1 A1 A1 [3]	Evidence of checking value at any vertex or using a sliding profit line Their x and y values at maximum in any exact form or correct to 3 sf Their maximum P value in any exact form or correct to 3 sf
	(iv)	x y $Q = 2x - y$ 2 1 3 2 2 2 ½ 1 0 $1\frac{1}{3}$ $2\frac{2}{3}$ 0 Q = **0** (x, y) can be any point on the **line segment joining (½, 1) and $(1\frac{1}{3}, 2\frac{2}{3})$**	M1 A1 A1 [3]	Evidence of checking value at any vertex or using a sliding profit line 0 (cao) The edge of the feasible region where $y = 2x$ No follow through
	(v)	$P = Q \Rightarrow 2x - y = x + 2y$ $\Rightarrow x = 3y$ $y = \frac{1}{3}x$ lies entirely in the shaded region	M1 A1 A1 [3]	For considering $P = Q$, or equivalent For this line, or any equivalent reasoning For explanation of why there are no solutions $\boxed{16}$

<table>
<tr><td>5</td><td>(i)</td><td>2x - 5y + 2z + s = 10
2x +3z + t = 30</td><td>B1 [1]</td><td>Slack variables used correctly</td></tr>
<tr><td></td><td>(ii)</td><td><table>
<tr><td>P</td><td>x</td><td>y</td><td>z</td><td>s</td><td>t</td><td></td></tr>
<tr><td>1</td><td>-1</td><td>2</td><td>3</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>2</td><td>-5</td><td>2</td><td>1</td><td>0</td><td>10</td></tr>
<tr><td>0</td><td>2</td><td>0</td><td>3</td><td>0</td><td>1</td><td>30</td></tr>
</table></td><td>M1

A1 [2]</td><td>For overall structure correct, including two slack variable columns and column for RHS (condone omission of P column or labels)
For a completely correct initial tableau, with no extra constraints added (condone variations in order of rows or columns)</td></tr>
<tr><td></td><td>(iii)</td><td>Pivot on x column since it is the only column with a negative value in the objective row
10 ÷ 2 = 5 5 < 15 so pivot on this row
30 ÷ 2 = 15</td><td>B1

B1 [2]</td><td>For negative in objective row, top row, pay-off row, or equivalent
For these two divisions shown</td></tr>
<tr><td></td><td>(iv)</td><td>New row 2 = row 2 ÷ 2
New row 1 = row 1 + new row 2
New row 3 = row 3 – 2 × new row 2</td><td>B1
B1 [2]</td><td>For dealing with the pivot row correctly
For dealing with the other rows correctly
May be coded by rows of table</td></tr>
<tr><td></td><td></td><td><table>
<tr><td>1</td><td>0</td><td>-0.5</td><td>4</td><td>0.5</td><td>0</td><td>5</td></tr>
<tr><td>0</td><td>1</td><td>-2.5</td><td>1</td><td>0.5</td><td>0</td><td>5</td></tr>
<tr><td>0</td><td>0</td><td>5</td><td>1</td><td>-1</td><td>1</td><td>20</td></tr>
</table></td><td>M1
M1
A1 [3]</td><td>For updating their pivot row correctly
For a reasonable attempt at updating other rows
For correct values in tableau (condone consistent order of rows or columns). Do not follow through errors in initial tableau or pivot choice.</td></tr>
<tr><td></td><td></td><td>x = 5, y = 0, z = 0
P = 5
Not the maximum feasible value of P since there is still a negative value in the objective row</td><td>B1
B1
B1 [3]</td><td>For reading off x, y and z from their tableau
For reading off P from their tableau
‘No’ seen or implied and a correct reason

13</td></tr>
</table>

6	(a)		 M1 M1 A1 B1 B1	ANSWERED ON INSERT Values correct at *B*, *D* and *E* (condone temporary labels implied from permanent labels) Both 54 and 37 seen at *H* and both 51 and 47 seen at *G* (method) All temporary labels correct <u>and no extras</u> All permanent labels correct Order of labelling correct (condone boxes consistently swapped over)
		A – E – H - J **48** metres	B1 B1 [7]	For this route, including end vertices (cao) For 48 (cao)
	(b) (i)	*A* and *J* are the only odd nodes 48 + 300 = **348** metres	B1 M1 A1 [3]	Identifying odd nodes (or by implication) For their 48 + 300 (or their 300) 348 (cao)
	(ii)	Odd nodes *A*, *B*, *H*, *J* *AB* = **24** *AH* = **37** *AJ* = **48** *HJ* = **11** *BJ* = **38** *BH* = **34** Repeat *AB* and *HJ* = 35 300 – 30 = 270 metres Shortest distance = 270 + 35 = **305** metres	B1 B1 B1 M1 M1 A1 [6]	Identifying odd nodes (or by implication) For distances from *A* – or from their Dijkstra For distances *HJ*, *BJ*, *BH* correct Choosing their least pairing or by implication Or by implication 305 (cao) $\boxed{16}$