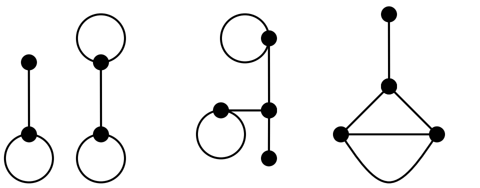
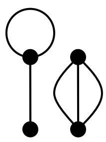
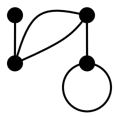
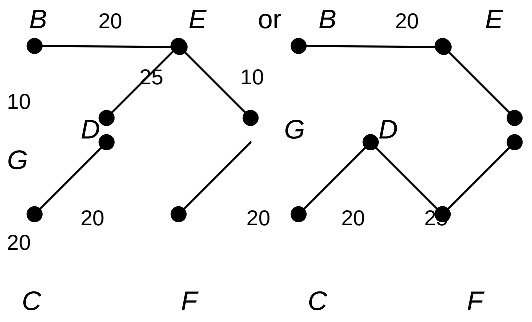
Mark Scheme 4736
June 2006

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 **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 **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 **≤ 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 **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 $1\frac{1}{3}$ $2\frac{2}{3}$ $6\frac{2}{3}$ $x = \mathbf{1\frac{1}{3}}$, $y = \mathbf{2\frac{2}{3}}$ (may be given in coordinate form) $P = \mathbf{6\frac{2}{3}}$	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 **16**

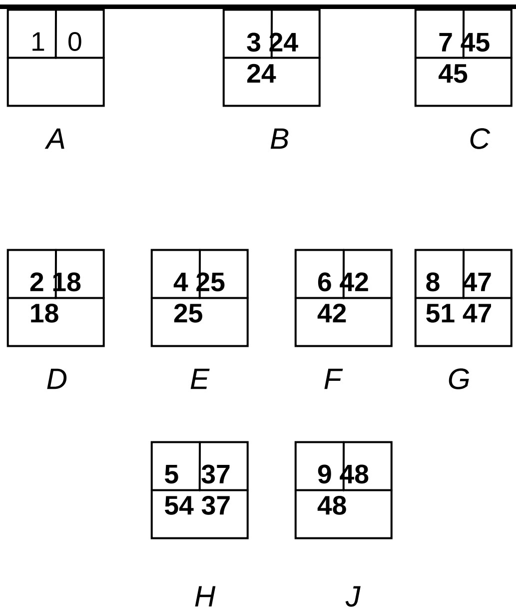
5	(i)	**$2x - 5y + 2z + s = 10$** **$2x + 3z + t = 30$**	B1 [1]	Slack variables used correctly
	(ii)	see tableau below	M1 A1 [2]	For overall structure correct, including two slack variable columns and column for RHS (condone omission of *P* column or labels) For a completely correct initial tableau, with no extra constraints added (condone variations in order of rows or columns)
	(iii)	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**	B1 B1 [2]	For negative in objective row, top row, pay-off row, or equivalent For these two divisions shown
	(iv)	New row 2 = **row 2 ÷ 2** New row 1 = **row 1 + new row 2** New row 3 = **row 3 – 2 × new row 2**	B1 B1 [2]	For dealing with the pivot row correctly For dealing with the other rows correctly May be coded by rows of table
		see tableau below	M1 M1 A1 [3]	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.
		***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**	B1 B1 B1 [3]	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

Initial tableau (ii):

P	*x*	*y*	*z*	*s*	*t*	
1	**-1**	**2**	**3**	**0**	**0**	**0**
0	**2**	**-5**	**2**	**1**	**0**	**10**
0	**2**	**0**	**3**	**0**	**1**	**30**

Updated tableau (iv):

1	**0**	**-0.5**	**4**	**0.5**	**0**	**5**
0	**1**	**-2.5**	**1**	**0.5**	**0**	**5**
0	**0**	**5**	**1**	**-1**	**1**	**20**

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) **16**