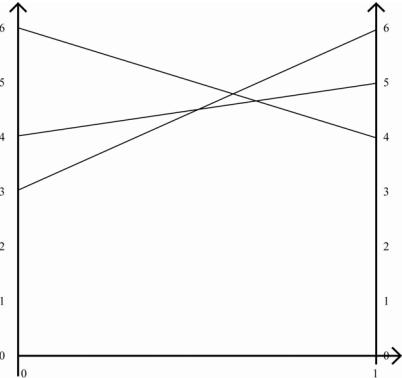


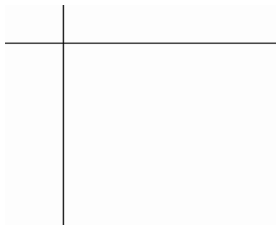
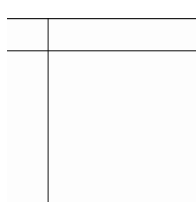
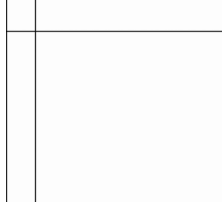
June 2008
6690 Decision Mathematics D2
Mark Scheme

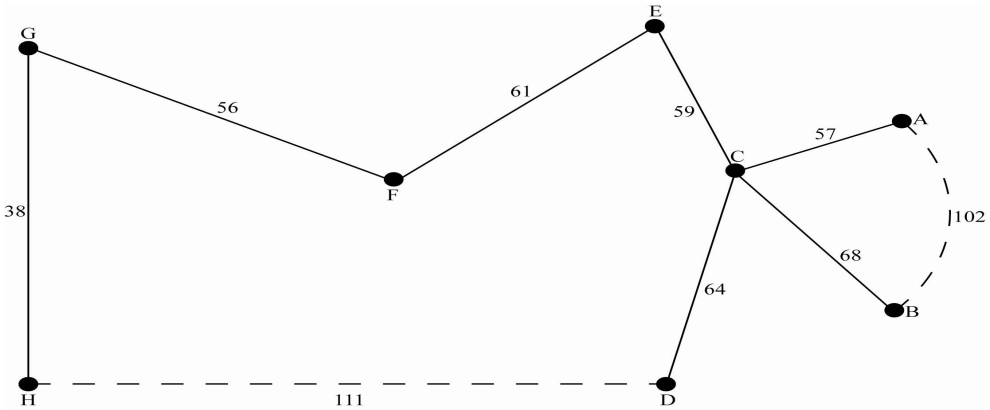
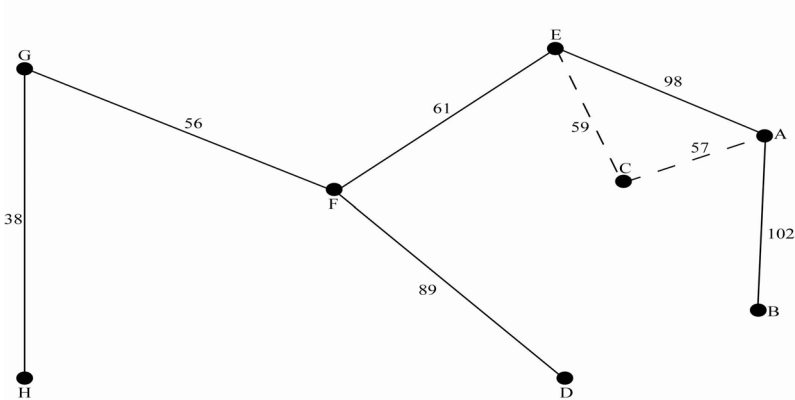
| Question Number | Scheme | Marks |
|-----------------|--|---|
| Q1 | <p>(a) A walk is a finite sequence of arcs such that the end vertex of one arc is the start vertex of the next.</p> <p>(b) A tour is a walk that visits every vertex, returning to its starting vertex.</p> <p>Notes: (a) 1B1: Probably one of the two below but accept correct relevant statement– bod gets B1, generous. 2B1: A good clear complete answer: End vertex=start vertex + finite. (b) 1B1: Probably one of the two below but accept correct relevant statement– bod gets B1, generous. 2B1: A good clear complete answer: Every vertex + return to start.</p> <p style="text-align: center;"><u>From the D1 and D2 glossaries</u></p> <p><u>D1</u> A path is a finite sequence of edges, such that the end vertex of one edge in the sequence is the start vertex of the next, <u>and in which no vertex appears more than once.</u></p> <p>A cycle (circuit) is a closed path, ie the end vertex of the last edge is the start vertex of the first edge.</p> <p><u>D2</u> A walk in a network is a finite sequence of edges such that the end vertex of one edge is the start vertex of the next.</p> <p>A walk which visits every vertex, returning to its starting vertex, is called a tour.</p> | <p>B2,1,0</p> <p>B2,1,0 (4)</p> <p>Total 4</p> |

| Question Number | Scheme | Marks | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------|--|--------------|-------------|----|---|---|----|----|--|---|--|----|---|--|--|----|----|----|--|--|---|---|---|---|---|----|----|--|-----|---|--|----|---|--|---|---|---|---|----|--------------|----------|---|--|--------------|-------------|--|--|----|----|---|--|--|---|---|---|---|---|----|----|---|-----|---|--|----|--|---|
| Q2 | <p>(a) Total supply > total demand</p> <p>(b) Adds 0, 0 and 5 to the dummy column</p> <p>(c) <table border="1"> <tr><td></td><td>L</td><td>E</td><td>D</td></tr> <tr><td>A</td><td>35</td><td>20</td><td></td></tr> <tr><td>B</td><td></td><td>40</td><td>5</td></tr> </table> </p> <p>(d) <table border="1"> <tr><td></td><td></td><td>80</td><td>70</td><td>20</td></tr> <tr><td></td><td></td><td>L</td><td>E</td><td>D</td></tr> <tr><td>0</td><td>A</td><td>35</td><td>20</td><td></td></tr> <tr><td>-20</td><td>B</td><td></td><td>40</td><td>5</td></tr> </table> $I_{AD} = 0 - 0 - 20 = -20$ $I_{BL} = 60 + 20 - 80 = 0$ <table border="1"> <tr><td></td><td>L</td><td>E</td><td>D</td></tr> <tr><td>A</td><td>35</td><td>20-θ</td><td>θ</td></tr> <tr><td>B</td><td></td><td>40+θ</td><td>5-θ</td></tr> </table> <p>$\theta = 5$; entering square is AD; exiting square is BD</p> <table border="1"> <tr><td></td><td></td><td>80</td><td>70</td><td>0</td></tr> <tr><td></td><td></td><td>L</td><td>E</td><td>D</td></tr> <tr><td>0</td><td>A</td><td>35</td><td>15</td><td>5</td></tr> <tr><td>-20</td><td>B</td><td></td><td>45</td><td></td></tr> </table> $I_{BL} = 60 + 20 - 80 = 0$ $I_{BD} = 0 + 20 - 0 = 20$ </p> | | L | E | D | A | 35 | 20 | | B | | 40 | 5 | | | 80 | 70 | 20 | | | L | E | D | 0 | A | 35 | 20 | | -20 | B | | 40 | 5 | | L | E | D | A | 35 | 20- θ | θ | B | | 40+ θ | 5- θ | | | 80 | 70 | 0 | | | L | E | D | 0 | A | 35 | 15 | 5 | -20 | B | | 45 | | <p>B2,1,0 (2)</p> <p>B2,1,0 (2)</p> <p>B1 (1)</p> <p>M1 A1</p> <p>A1ft (3)</p> <p>M1</p> <p>A1ft (2)</p> <p>B1ft</p> <p>B1ft (2)</p> <p>B1 (1)</p> <p>Total 13</p> |
| | L | E | D | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| A | 35 | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| B | | 40 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 80 | 70 | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | L | E | D | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | A | 35 | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| -20 | B | | 40 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | L | E | D | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| A | 35 | 20- θ | θ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| B | | 40+ θ | 5- θ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 80 | 70 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | L | E | D | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | A | 35 | 15 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| -20 | B | | 45 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Question Number | Scheme | Marks | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------|---|--------|-------|-------------------------|-------|-------|--|---|----|---|------|---|---|----|---|------|--|---|----|---|------|--|---|----|---|-----------------------|--|--|----|---|-------------------------|---|---|----|---|-----------------------|--|--|----|---|-------------------------|--|--|----|---|-----------------------|--|---|----|---|-------------------------|--|--|----|---|-----------------------|--|---|----|---|-------------------------|--|--|----|---|-----------------------|---|---|----|---|-----------------------|--|--|----|---|-------------------------|--|--|----|---|-----------------------|--|---|----|---|-----------------------|--|--|----|---|-------------------------|--|---|----|---|-------------------------|---|--|----|---|-----------------------|--|--|----|---|-----------------------|--|
| Q3 | <p>(a) Maximin : we seek a route where the shortest arc used is a great as possible. Minimax : we seek a route where the longest arc used is a small as possible.</p> <p>(b)</p> <table border="1"> <thead> <tr> <th>Stage</th> <th>State</th> <th>Action</th> <th>Dest.</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td></td> <td>G</td> <td>GR</td> <td>R</td> <td>132*</td> </tr> <tr> <td>1</td> <td>H</td> <td>HR</td> <td>R</td> <td>175*</td> </tr> <tr> <td></td> <td>I</td> <td>IR</td> <td>R</td> <td>139*</td> </tr> <tr> <td></td> <td>D</td> <td>DG</td> <td>G</td> <td>$\min(175,132) = 132$</td> </tr> <tr> <td></td> <td></td> <td>DH</td> <td>H</td> <td>$\min(160,175) = 160^*$</td> </tr> <tr> <td>2</td> <td>E</td> <td>EG</td> <td>G</td> <td>$\min(162,132) = 132$</td> </tr> <tr> <td></td> <td></td> <td>EH</td> <td>H</td> <td>$\min(144,175) = 144^*$</td> </tr> <tr> <td></td> <td></td> <td>EI</td> <td>I</td> <td>$\min(102,139) = 102$</td> </tr> <tr> <td></td> <td>F</td> <td>FH</td> <td>H</td> <td>$\min(145,175) = 145^*$</td> </tr> <tr> <td></td> <td></td> <td>FI</td> <td>I</td> <td>$\min(210,139) = 139$</td> </tr> <tr> <td></td> <td>A</td> <td>AD</td> <td>D</td> <td>$\min(185,160) = 160^*$</td> </tr> <tr> <td></td> <td></td> <td>AE</td> <td>E</td> <td>$\min(279,144) = 144$</td> </tr> <tr> <td>3</td> <td>B</td> <td>BD</td> <td>D</td> <td>$\min(119,160) = 119$</td> </tr> <tr> <td></td> <td></td> <td>BE</td> <td>E</td> <td>$\min(250,144) = 144^*$</td> </tr> <tr> <td></td> <td></td> <td>BF</td> <td>F</td> <td>$\min(123,145) = 123$</td> </tr> <tr> <td></td> <td>C</td> <td>CE</td> <td>E</td> <td>$\min(240,144) = 144$</td> </tr> <tr> <td></td> <td></td> <td>CF</td> <td>F</td> <td>$\min(170,145) = 145^*$</td> </tr> <tr> <td></td> <td>L</td> <td>LA</td> <td>A</td> <td>$\min(155,160) = 155^*$</td> </tr> <tr> <td>4</td> <td></td> <td>LB</td> <td>B</td> <td>$\min(190,144) = 144$</td> </tr> <tr> <td></td> <td></td> <td>LC</td> <td>C</td> <td>$\min(148,145) = 145$</td> </tr> </tbody> </table> <p>Maximin route: LADHR</p> | Stage | State | Action | Dest. | Value | | G | GR | R | 132* | 1 | H | HR | R | 175* | | I | IR | R | 139* | | D | DG | G | $\min(175,132) = 132$ | | | DH | H | $\min(160,175) = 160^*$ | 2 | E | EG | G | $\min(162,132) = 132$ | | | EH | H | $\min(144,175) = 144^*$ | | | EI | I | $\min(102,139) = 102$ | | F | FH | H | $\min(145,175) = 145^*$ | | | FI | I | $\min(210,139) = 139$ | | A | AD | D | $\min(185,160) = 160^*$ | | | AE | E | $\min(279,144) = 144$ | 3 | B | BD | D | $\min(119,160) = 119$ | | | BE | E | $\min(250,144) = 144^*$ | | | BF | F | $\min(123,145) = 123$ | | C | CE | E | $\min(240,144) = 144$ | | | CF | F | $\min(170,145) = 145^*$ | | L | LA | A | $\min(155,160) = 155^*$ | 4 | | LB | B | $\min(190,144) = 144$ | | | LC | C | $\min(148,145) = 145$ | <p>B2,1,0 (2)</p> <p>M1A1 (2)</p> <p>M1A1</p> <p>A1 (3)</p> <p>M1A1ft</p> <p>A1ft</p> <p>A1ft</p> <p>A1ft</p> <p>A1ft (5)</p> <p>Total 12</p> |
| Stage | State | Action | Dest. | Value | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | G | GR | R | 132* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | H | HR | R | 175* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | I | IR | R | 139* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | D | DG | G | $\min(175,132) = 132$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | DH | H | $\min(160,175) = 160^*$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | E | EG | G | $\min(162,132) = 132$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | EH | H | $\min(144,175) = 144^*$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | EI | I | $\min(102,139) = 102$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | F | FH | H | $\min(145,175) = 145^*$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | FI | I | $\min(210,139) = 139$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | A | AD | D | $\min(185,160) = 160^*$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | AE | E | $\min(279,144) = 144$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | B | BD | D | $\min(119,160) = 119$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | BE | E | $\min(250,144) = 144^*$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | BF | F | $\min(123,145) = 123$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | C | CE | E | $\min(240,144) = 144$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | CF | F | $\min(170,145) = 145^*$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | L | LA | A | $\min(155,160) = 155^*$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | LB | B | $\min(190,144) = 144$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | LC | C | $\min(148,145) = 145$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Question Number | Scheme | Marks | | | | | | | | | | | | |
|-----------------|--|-------|----|----|----|----|---|---|---|----|---|---|---|---|
| Q4 | <p>(a) For each row the element in column x must be less than the element in column y.</p> <p>(b) Row minimum {2,4,3} row maximin = 4 Column maximum {6,5,6} column minimax = 5 4 ≠ 5 so not stable</p> <p>(c) Row 3 dominates row 1, so matrix reduces to</p> <table border="1"> <thead> <tr> <th></th> <th>M1</th> <th>M2</th> <th>M3</th> </tr> </thead> <tbody> <tr> <th>L2</th> <td>4</td> <td>5</td> <td>6</td> </tr> <tr> <th>L3</th> <td>6</td> <td>4</td> <td>3</td> </tr> </tbody> </table> <p>Let Liz play 2 with probability p and 3 with probability (1- p) If Mark plays 1: Liz's gain is $4p + 6(1-p) = 6 - 2p$ If Mark plays 2: Liz's gain is $5p + 4(1-p) = 4 + p$ If Mark plays 3: Liz's gain is $6p + 3(1-p) = 3 + 3p$</p>  <p>$4 + p = 6 - 2p$ $p = \frac{2}{3}$</p> <p>Liz should play row 1 – never, row 2 - $\frac{2}{3}$ of the time, row 3 - $\frac{1}{3}$ of the time and the value of the game is $4\frac{2}{3}$ to her.</p> <p>(d) Row 3 no longer dominates row 1 and so row 1 can not be deleted. Use Simplex (linear programming).</p> | | M1 | M2 | M3 | L2 | 4 | 5 | 6 | L3 | 6 | 4 | 3 | <p>B2,1,0 (2)</p> <p>M1 A1 A1 (3)</p> <p>B1</p> <p>M1 A1 (3)</p> <p>B2, 1ft, 0 (2)</p> <p>M1 A1</p> <p>A1ft A1 (4)</p> <p>B1 B1 (2) Total 16</p> |
| | M1 | M2 | M3 | | | | | | | | | | | |
| L2 | 4 | 5 | 6 | | | | | | | | | | | |
| L3 | 6 | 4 | 3 | | | | | | | | | | | |

| Question Number | Scheme | Marks | | | | | | | | | | | | |
|-----------------|--|-------|---|---|-----------|---|---|--------|---|---|--------|---|---|--|
| Q5 | <p>(a) Since maximising, subtract all elements from some $n \geq 53$</p> $\begin{bmatrix} 5 & 4 & 11 & 11 \\ 0 & 4 & 2 & 3 \\ 2 & 0 & 5 & 5 \\ 6 & 3 & 7 & 10 \end{bmatrix}$ <p>Reduce rows $\begin{bmatrix} 1 & 0 & 7 & 7 \\ 0 & 4 & 2 & 3 \\ 2 & 0 & 5 & 5 \\ 3 & 0 & 4 & 7 \end{bmatrix}$ then columns $\begin{bmatrix} 1 & 0 & 5 & 4 \\ 0 & 4 & 0 & 0 \\ 2 & 0 & 3 & 2 \\ 3 & 0 & 2 & 4 \end{bmatrix}$</p> <p>Minimum element 1</p>  $\begin{bmatrix} 0 & 0 & 4 & 3 \\ 0 & 5 & 0 & 0 \\ 1 & 0 & 2 & 1 \\ 2 & 0 & 1 & 3 \end{bmatrix}$   $\begin{bmatrix} 0 & 1 & 4 & 3 \\ 0 & 6 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 2 \end{bmatrix}$ $\begin{bmatrix} 0 & 0 & 3 & 2 \\ 1 & 6 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 2 & 0 & 0 & 2 \end{bmatrix}$ <p>(b)</p> <table border="1"> <tr> <td>Joe</td> <td>A</td> <td>A</td> </tr> <tr> <td>Min-Seong</td> <td>C</td> <td>D</td> </tr> <tr> <td>Olivia</td> <td>D</td> <td>B</td> </tr> <tr> <td>Robert</td> <td>B</td> <td>C</td> </tr> </table> <p>Value £197 000</p> | Joe | A | A | Min-Seong | C | D | Olivia | D | B | Robert | B | C | <p>M1 A1 (2)</p> <p>M1 A1ft (2)</p> <p>M1</p> <p>A1ft</p> <p>A1ft (3)</p> <p>M1</p> <p>A1ft</p> <p>A1ft (3)</p> <p>M1 A1ft (2)</p> <p>M1A1 (2) Total 14</p> |
| Joe | A | A | | | | | | | | | | | | |
| Min-Seong | C | D | | | | | | | | | | | | |
| Olivia | D | B | | | | | | | | | | | | |
| Robert | B | C | | | | | | | | | | | | |

| Question Number | Scheme | Marks |
|-----------------|--|--|
| Q6 | <p>(a) GH(38) GF(56) CA(57) EC(59) FE(61) CD(64) CB(68)</p> <p>(b) $2 \times 403 = 806$ (km)</p> <p>(c) e.g. DH saves 167 AB saves 23 $806 - 190 = 616$ (km)</p>  <p>eg ABC EFGH DCA</p> <p>(d) B C A E F G H D B $63 + 57 + 98 + 61 + 56 + 38 + 111 + 108 = 597$ (km)</p> <p>(e) Delete C</p>  <p>RMST weight = 444 Lower bound = $444 + 59 + 57 = 560$ (km)</p> <p>(f) $560 < \text{length} \leq 597$</p> | <p>M1A1 (2)</p> <p>B1 (1)</p> <p>M1 A1</p> <p>A1</p> <p>A1 (4)</p> <p>M1 A1</p> <p>A1 (3)</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1ft (4)</p> <p>B2,1,0 (2)</p> <p>Total 16</p> |

6690 JUNE 2008 Question 2 notes

- (a) 1B1: Close, accept supply \neq demand
2B1: CAO
- (b) 1B1: One error
2B1: CAO
- (c) 1B1: CAO
- (d) 1M1: 5 shadow costs and precisely 2 improvement indices stated (no extra zeros)
1A1: 5 shadow costs correct.
2A1: 2 improvement indices correct.
2M1: A valid route, negative II chosen, only one empty square used, θ 's balance.
3A1ft: optimal solution (no extra zeros)
1B1ft: ft 5 correct shadow costs
2B1ft: ft precisely 2 Improvement indices, both correct (no extra zeros)
- (e) 1B1: CAO condone lack of £s

Note There is a second correct solution. It is unlikely to be found except as a result of an earlier error, or in continuing to develop the solution on mark scheme.

| | | | | |
|-----|---|----|----|---|
| | | 80 | 70 | 0 |
| | | L | E | D |
| 0 | A | | 50 | 5 |
| -20 | B | 35 | 10 | |

$$I_{AL} = 80 - 0 - 80 = 0 \quad I_{BD} = 0 + 20 - 0 = 20 \quad \text{Cost (£) } 1600$$

(d) Accept

| | | | | | | | | | |
|----|---|----|-----|-----|----|---|----|-----|-----|
| | | 0 | -10 | -60 | | | 0 | -10 | -80 |
| | | L | E | D | | | L | E | D |
| 80 | A | 35 | 20 | | 80 | A | 35 | 15 | 5 |
| 60 | B | | 40 | 5 | 60 | B | | 45 | |

Do not accept

| | | | | | | | | | |
|----|---|----|----|-----|----|---|----|----|---|
| | | 35 | 20 | -15 | | | 35 | 15 | 5 |
| | | L | E | D | | | L | E | D |
| 0 | A | 35 | 20 | | 0 | A | 35 | 15 | 5 |
| 20 | B | | 40 | 5 | 30 | B | | 45 | |

| | | | | | | | | | |
|----|---|----|-----|-----|----|---|----|-----|-----|
| | | 0 | -15 | -60 | | | 0 | -20 | -30 |
| | | L | E | D | | | L | E | D |
| 35 | A | 35 | 20 | | 35 | A | 35 | 15 | 5 |
| 65 | B | | 40 | 5 | 65 | B | | 45 | |

6690 JUNE 2008 Question 3 notes

- (a) 1B1: Close. Condone swapped definitions here. bod gets B1.
2B1: Good, clear answer.

Throughout section (b):

- **Condone lack of destination column and/or reversed stage numbers throughout.**
- **Only penalise incorrect result in Value – ie ignore working values.**
- **Penalise absence of state or action column with first two A marks earned only**
- **Penalise empty/errors in stage column with first A mark earned only.**

- (b) 1M1: First stage complete and working backwards.
1A1: CAO (condone lack of *)
2M1: Second stage completed. Penalise reversed states here and at end. Bod if something in each column.
2A1: Any 2 states correct. Penalise * errors with the first A mark earned here and only once.
3A1: All 3 states correct. (Penalise * errors only once in the question).
3M1: 3rd and 4th stages completed. Bod if something in each column.
4A1ft: Any 2 states correct. (Penalise * errors only once in the question). A, B or C
5A1ft: All 3 states correct. (Penalise * errors only once in the question). A, B and C.
6A1ft: Final, L, state correct. (Penalise * errors only once in the question).
7A1ft: CAO penalise reversed states again here.

Special cases (and misreads)

| | |
|---|-----------------|
| SC1 Minimax: treat as misread – see sheet. | MAX 8/10 |
| SC2 Maximum: 1M1,1A1; 2M0; 3M1,4A1ft,5A0,6A1ft,7A1ft | MAX 6/10 |
| SC3 Minimum: Marks awarded as above SC2 | |
| SC4 Maximax: 1M1,1A1; 2M0; 3M1,4A0,5A0,6A0,7A1ft | MAX 4/10 |
| SC5 Minimin: Marks awarded as above SC4 | |
| SC6 Working forwards: see sheet. | MAX 4/10 |

Anything else annotate and send to review.

| Question Number | Scheme | Marks | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------|--|--------|-------|-----------------------|------|-------|--|---|----|---|------|---|---|----|---|------|--|---|----|---|------|--|---|----|---|-----------------------|--|--|----|---|-----------------------|---|---|----|---|----------------------|--|--|----|---|----------------------|--|--|----|---|-----------------------|--|---|----|---|-----------------------|--|--|----|---|----------------------|--|---|----|---|-----------------------|--|--|----|---|----------------------|---|---|----|---|-----------------------|--|--|----|---|----------------------|--|--|----|---|-----------------------|--|---|----|---|----------------------|--|--|----|---|-----------------------|--|---|----|---|----------------------|---|--|----|---|----------------------|--|--|----|---|-----------------------|--|
| Q3(b) | <p style="text-align: center;"><u>SC1 (Minimax – MISREAD)</u></p> <p>Misread: Award marks as usual. Remove the last 2 A (or B) marks earned</p> <p>ANNOTATE: MR</p> <table border="1"> <thead> <tr> <th>Stage</th> <th>State</th> <th>Action</th> <th>Dest</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td></td> <td>G</td> <td>GR</td> <td>R</td> <td>132*</td> </tr> <tr> <td>1</td> <td>H</td> <td>HR</td> <td>R</td> <td>175*</td> </tr> <tr> <td></td> <td>I</td> <td>IR</td> <td>R</td> <td>139*</td> </tr> <tr> <td></td> <td>D</td> <td>DG</td> <td>G</td> <td>max (175, 132) = 175*</td> </tr> <tr> <td></td> <td></td> <td>DH</td> <td>H</td> <td>max (160, 175) = 175*</td> </tr> <tr> <td>2</td> <td>E</td> <td>EG</td> <td>G</td> <td>max (162, 132) = 162</td> </tr> <tr> <td></td> <td></td> <td>EH</td> <td>H</td> <td>max (144, 175) = 175</td> </tr> <tr> <td></td> <td></td> <td>EI</td> <td>I</td> <td>max (102, 139) = 139*</td> </tr> <tr> <td></td> <td>F</td> <td>FH</td> <td>H</td> <td>max (145, 175) = 175*</td> </tr> <tr> <td></td> <td></td> <td>FI</td> <td>I</td> <td>max (210, 139) = 210</td> </tr> <tr> <td></td> <td>A</td> <td>AD</td> <td>D</td> <td>max (185, 175) = 185*</td> </tr> <tr> <td></td> <td></td> <td>AE</td> <td>E</td> <td>max (279, 139) = 279</td> </tr> <tr> <td>3</td> <td>B</td> <td>BD</td> <td>D</td> <td>max (119, 175) = 175*</td> </tr> <tr> <td></td> <td></td> <td>BE</td> <td>E</td> <td>max (250, 139) = 250</td> </tr> <tr> <td></td> <td></td> <td>BF</td> <td>F</td> <td>max (123, 175) = 175*</td> </tr> <tr> <td></td> <td>C</td> <td>CE</td> <td>E</td> <td>max (240, 139) = 240</td> </tr> <tr> <td></td> <td></td> <td>CF</td> <td>F</td> <td>max (170, 175) = 175*</td> </tr> <tr> <td></td> <td>L</td> <td>LA</td> <td>A</td> <td>max (155, 185) = 185</td> </tr> <tr> <td>4</td> <td></td> <td>LB</td> <td>B</td> <td>max (190, 175) = 190</td> </tr> <tr> <td></td> <td></td> <td>LC</td> <td>C</td> <td>max (148, 175) = 175*</td> </tr> </tbody> </table> <p style="text-align: center;">LCFHR</p> | Stage | State | Action | Dest | Value | | G | GR | R | 132* | 1 | H | HR | R | 175* | | I | IR | R | 139* | | D | DG | G | max (175, 132) = 175* | | | DH | H | max (160, 175) = 175* | 2 | E | EG | G | max (162, 132) = 162 | | | EH | H | max (144, 175) = 175 | | | EI | I | max (102, 139) = 139* | | F | FH | H | max (145, 175) = 175* | | | FI | I | max (210, 139) = 210 | | A | AD | D | max (185, 175) = 185* | | | AE | E | max (279, 139) = 279 | 3 | B | BD | D | max (119, 175) = 175* | | | BE | E | max (250, 139) = 250 | | | BF | F | max (123, 175) = 175* | | C | CE | E | max (240, 139) = 240 | | | CF | F | max (170, 175) = 175* | | L | LA | A | max (155, 185) = 185 | 4 | | LB | B | max (190, 175) = 190 | | | LC | C | max (148, 175) = 175* | <p>M1 A1 (2)</p> <p>M1 A1</p> <p>A1 (3)</p> <p>M1 A1ft</p> <p>A1ft</p> <p>A1ft</p> <p>A1ft (5)</p> <p>- last 2 A/B for MR</p> |
| Stage | State | Action | Dest | Value | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | G | GR | R | 132* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | H | HR | R | 175* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | I | IR | R | 139* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | D | DG | G | max (175, 132) = 175* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | DH | H | max (160, 175) = 175* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | E | EG | G | max (162, 132) = 162 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | EH | H | max (144, 175) = 175 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | EI | I | max (102, 139) = 139* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | F | FH | H | max (145, 175) = 175* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | FI | I | max (210, 139) = 210 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | A | AD | D | max (185, 175) = 185* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | AE | E | max (279, 139) = 279 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | B | BD | D | max (119, 175) = 175* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | BE | E | max (250, 139) = 250 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | BF | F | max (123, 175) = 175* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | C | CE | E | max (240, 139) = 240 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | CF | F | max (170, 175) = 175* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | L | LA | A | max (155, 185) = 185 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | LB | B | max (190, 175) = 190 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | LC | C | max (148, 175) = 175* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Question Number | Scheme | | | | Marks | | | |
|-----------------|-----------------------------|--------------|---------------|-------------|--------------|---------------------|----------|------------------------------------|
| Q3(b) | <u>SC2 (Maximum)</u> | | | | | | | |
| | Stage | State | Action | Dest | | Value | | |
| | | G | GR | R | | 132* | M1 A1 | |
| | 1 | H | HR | R | | 175* | | |
| | | I | IR | R | | 139* | | |
| | | D | DG | G | | $175 + 132 = 307$ | M0 | |
| | | | DH | H | | $160 + 175 = 335^*$ | | |
| | 2 | E | EG | G | | $162 + 132 = 294$ | | |
| | | | EH | H | | $144 + 175 = 319^*$ | | |
| | | | EI | I | | $102 + 139 = 241$ | | |
| | | F | FH | H | | $145 + 175 = 320$ | | |
| | | | FI | I | | $210 + 139 = 349^*$ | | |
| | | A | AD | D | | $185 + 335 = 520$ | | |
| | | | AE | E | | $279 + 319 = 598^*$ | | M1 A1ft (for ALL correct) A0 |
| | 3 | B | BD | D | | $119 + 335 = 454$ | | |
| | | | BE | E | | $250 + 319 = 569^*$ | | |
| | | | BF | F | | $123 + 349 = 472$ | | |
| | | C | CE | E | | $240 + 319 = 559^*$ | | |
| | | | CF | F | | $170 + 349 = 519$ | | |
| | | L | LA | A | | $155 + 598 = 753$ | A1ft | |
| | 4 | | LB | B | | $190 + 569 = 759^*$ | | |
| | | | LC | C | | $148 + 559 = 707$ | | |
| | | RHEBL | | | | A1ft | | |
| | | | | | 6 max | | | |

| Question Number | Scheme | | | | Marks | | |
|-----------------|-----------------------------|--------------|---------------|-------------|--------------|---------------------|-------------------|
| Q3(b) | <u>SC3 (Minimum)</u> | | | | | | |
| | Stage | State | Action | Dest | | Value | |
| | | G | GR | R | | 132* | M1 |
| | 1 | H | HR | R | | 175* | A1 |
| | | I | IR | R | | 139* | |
| | | D | DG | G | | $175 + 132 = 307^*$ | |
| | | | DH | H | | $160 + 175 = 335$ | |
| | 2 | E | EG | G | | $162 + 132 = 294$ | M0 |
| | | | EH | H | | $144 + 175 = 319$ | |
| | | | EI | I | | $102 + 139 = 241^*$ | |
| | | F | FH | H | | $145 + 175 = 320^*$ | |
| | | | FI | I | | $210 + 139 = 349$ | |
| | | A | AD | D | | $185 + 307 = 492^*$ | M1 A1ft |
| | | | AE | E | | $279 + 241 = 520$ | (for ALL correct) |
| | 3 | B | BD | D | | $119 + 307 = 426^*$ | A0 |
| | | | BE | E | | $250 + 241 = 491$ | |
| | | | BF | F | | $123 + 320 = 443$ | |
| | | C | CE | E | | $240 + 241 = 481^*$ | |
| | | | CF | F | | $170 + 320 = 490$ | |
| | | L | LA | A | | $155 + 492 = 647$ | |
| | 4 | | LB | B | | $190 + 426 = 616^*$ | A1ft |
| | | | LC | C | | $148 + 481 = 629$ | |
| | | RGDBL | | | | A1ft | |
| | | | | | 6 max | | |

| Question Number | Scheme | | | | Marks | | |
|-----------------|-----------------------------|--------------|---------------|-------------|-------|--------------------------|----|
| Q3(b) | <u>SC4 (Maximax)</u> | | | | | | |
| | Stage | State | Action | Dest | | Value | |
| | | G | GR | R | | 132* | M1 |
| | 1 | H | HR | R | | 175* | A1 |
| | | I | IR | R | | 139* | |
| | | D | DG | G | | $\max(175, 132) = 175^*$ | |
| | | | DH | H | | $\max(160, 175) = 175^*$ | |
| | 2 | E | EG | G | | $\max(162, 132) = 162$ | M0 |
| | | | EH | H | | $\max(144, 175) = 175^*$ | |
| | | | EI | I | | $\max(102, 139) = 139$ | |
| | | F | FH | H | | $\max(145, 175) = 175$ | |
| | | | FI | I | | $\max(210, 139) = 210^*$ | |
| | | A | AD | D | | $\max(185, 175) = 185$ | M1 |
| | | | AE | E | | $\max(279, 175) = 279^*$ | A0 |
| | 3 | B | BD | D | | $\max(119, 175) = 175$ | A0 |
| | | | BE | E | | $\max(250, 175) = 250^*$ | |
| | | | BF | F | | $\max(123, 210) = 210$ | |
| | | C | CE | E | | $\max(240, 175) = 240^*$ | |
| | | | CF | F | | $\max(170, 210) = 210$ | |
| | | L | LA | A | | $\max(155, 279) = 279^*$ | |
| | 4 | | LB | B | | $\max(190, 250) = 250$ | A0 |
| | | | LC | C | | $\max(148, 240) = 240$ | |
| | RHEAL | | | | | A1ft | |
| | 4 max | | | | | | |

| Question Number | Scheme | | | | Marks | | |
|-----------------|-----------------------------|--------------|---------------|-------------|-------|--------------------------|--------------|
| Q3(b) | <u>SC5 (Minimin)</u> | | | | | | |
| | Stage | State | Action | Dest | | Value | |
| | | G | GR | R | | 132* | M1 |
| | 1 | H | HR | R | | 175* | A1 |
| | | I | IR | R | | 139* | |
| | | D | DG | G | | $\min(175, 132) = 132^*$ | |
| | | | DH | H | | $\min(160, 175) = 160$ | |
| | 2 | E | EG | G | | $\min(162, 132) = 132$ | M0 |
| | | | EH | H | | $\min(144, 175) = 144$ | |
| | | | EI | I | | $\min(102, 139) = 102^*$ | |
| | | F | FH | H | | $\min(145, 175) = 145$ | |
| | | | FI | I | | $\min(210, 139) = 139^*$ | |
| | | A | AD | D | | $\min(185, 132) = 132$ | M1 |
| | | | AE | E | | $\min(279, 102) = 102^*$ | A0 |
| | 3 | B | BD | D | | $\min(119, 132) = 119$ | A0 |
| | | | BE | E | | $\min(250, 102) = 102^*$ | |
| | | | BF | F | | $\min(123, 139) = 123$ | |
| | | C | CE | E | | $\min(240, 102) = 102^*$ | |
| | | | CF | F | | $\min(170, 139) = 139$ | |
| | | L | LA | A | | $\min(155, 102) = 102^*$ | A0 |
| | 4 | | LB | B | | $\min(190, 102) = 102^*$ | |
| | | | LC | C | | $\min(148, 102) = 102^*$ | |
| | RIEAL RIEBL RIECL | | | | | A1ft | 4 max |

| Question Number | Scheme | | | | Marks | | |
|-----------------|--|--------------|---------------|-------------|-------|--------------------------|-------------------------------------|
| Q3(b) | <u>SC6 (Working forwards + Maximin)</u> | | | | | | |
| | Stage | State | Action | Dest | | Value | |
| | | A | AL | L | | 155* | M0 |
| | 1 | B | BL | L | | 190* | |
| | | C | CL | L | | 148* | |
| | | D | DA | A | | $\min(185, 155) = 155^*$ | M1 A1 (for ALL correct) A0 |
| | | | DB | B | | $\min(119, 190) = 119$ | |
| | 2 | E | EA | A | | $\min(279, 155) = 155$ | |
| | | | EB | B | | $\min(250, 190) = 190^*$ | |
| | | | EC | C | | $\min(240, 148) = 148$ | |
| | | F | FB | B | | $\min(123, 190) = 123$ | |
| | | | FC | C | | $\min(170, 148) = 148^*$ | M1 A1ft (for ALL correct) A0 |
| | | G | GD | D | | $\min(175, 155) = 155$ | |
| | | | GE | E | | $\min(162, 190) = 162^*$ | |
| | 3 | H | HD | D | | $\min(160, 155) = 155^*$ | |
| | | | HE | E | | $\min(144, 190) = 144$ | |
| | | | HF | F | | $\min(145, 148) = 145$ | |
| | | I | IE | E | | $\min(102, 190) = 102$ | A0 A0 |
| | | | IF | F | | $\min(210, 148) = 148^*$ | |
| | | R | RG | G | | $\min(132, 162) = 132$ | |
| | 4 | | RH | H | | $\min(175, 155) = 155^*$ | A0 |
| | | | RI | I | | $\min(139, 148) = 139$ | A0 |
| | RHDAL | | | | | 4 max | |

6690 JUNE 2008 Question 4 notes

- (a) 1B1: bod. Give if confused column domination and row domination. Generous.
2B1: Good clear answer.
- (b) 1M1: Finds row maximin and column minimax. All values enough.
1A1: Row maximin = 4 col minimax = 5 identified in some way.
2A1: Row maximin (4) \neq column minimax (5) stated and a clear link to statement.
- (c) 1B1: Matrix reduced correctly. Could be implicit from equations.
1M1: Setting up three probability equations, implicit definition of p.
1A1: CAO
2B1ft: At least two lines correct, accept $p > 1$ or $p < 0$ here.
3B1: 3 lines cao, $0 \leq p \leq 1$, scale clear (or 1 line = 1), condone lack of labels.
2M1: Finding their correct optimal point, must have three lines, and setting up an equation to find $0 \leq p \leq 1$.
1A1: CAO
2A1ft: All three options listed.
3A1: CAO
- (d) 1B1: CAO (generous)
2B1: CAO (generous)

6690 JUNE 2008 Question 5 notes

- (a) 1M1: Subtracting from some $n \geq 53$
1A1: CAO
2M1: Reducing rows then columns
2A1ft: ft
3M1: Double covered +e; one uncovered – e; and one single covered unchanged.
3A1ft: ft correct accept one error
4A1ft: ft correct - no errors
4M1: Double covered +e; one uncovered – e; and one single covered unchanged.
5A1ft: ft correct accept one error
6A1ft: ft correct - no errors
- (b) 1M1: One complete solution.
1A1ft: ft all possible solutions for their diagram
2M1: ft their result – should be 197
2A1: cao (£) 197 000

MISREAD – minimises

$$\text{Reduce rows } \begin{bmatrix} 6 & 7 & 0 & 0 \\ 4 & 0 & 2 & 1 \\ 3 & 5 & 0 & 0 \\ 4 & 7 & 3 & 0 \end{bmatrix} \quad \text{then reduce columns } \begin{bmatrix} 3 & 7 & 0 & 0 \\ 1 & 0 & 2 & 1 \\ 0 & 5 & 0 & 0 \\ 1 & 7 & 3 & 0 \end{bmatrix}$$

This is optimal. J – C
 M – B
 O – A
 R – D
Cost (£) 185 000

Marks:

(a) 1M0 2M1 and 2A1 available. 3M0 4M0

(b) 1M1 1A1 2M0 2AO

Max of 4/ 14

6690 JUNE 2008 Question 6 notes

- (a) 1M1: First three arcs correct
1A1: CAO
- (b) 1B1: CAO 806
- (c) 1M1: Finding at least one shortcut, **must be shortcut method so shortcuts need to be clear**, stated or drawn.
1A1: At least two short cuts clear, stated or drawn, valid tour remains.
2DA1: depends on 1st A. Bound stated, below 630, valid tour remains. Consistent.
3DA1: depends on 2nd A. A correct, consistent tour stated for a value below 630. Accept a diagram with letters.
- (d) 1M1: Nearest Neighbour each vertex visited at least once (condone lack of return to start)
1A1: Correct route CAO – must return to start.
2A1: 597 CAO (do not ignore subsequent doubling)
- (e) 1M1: Finding correct RMST (maybe implicit) 444 sufficient, or correct numbers. 6 arcs.
1A1: CAO tree or 444.
2M1: Adding 2 least arcs to C, 57 and 59 or 116 only
2A1: CAO 560
- (f) 1B1: CSO 560 + all marks in (e). Accept better, correct lower bound
2B: CSO all marks in (c) and (d) 597 or 592

(c) **Some shortcuts**

| | A | B | C | D | E | F | G | H |
|---|----|----|----|-----|----|----|----|-----|
| A | | 23 | | | 18 | | | |
| B | 23 | | | 24 | | | | |
| C | | | | | | 45 | | |
| D | | 24 | | | | 95 | | 167 |
| E | 18 | | | | | | 30 | |
| F | | | 45 | 95 | | | | 19 |
| G | | | | | 30 | | | |
| H | | | | 167 | | 19 | | |

Some routes and lengths

| | | | |
|-------------------|------------|------------------|------------|
| ABCDFHGEA | 607 | ABDHFGECA | 655 |
| ABCDHFGEA | 661 | ABDHGEFCA | 639 |
| ABCDHGFEA | 598 | ABDHGFCEA | 647 |
| ABCDHGFCEA | 616 | ABDHGFCEA | 592 |
| ABCEFGHDCA | 616 | ACBDFHGEA | 620 |
| ABCDFHGEA | 668 | ACBDHFGEA | 660 |
| ABDCFHGEA | 647 | ACBDHGFEA | 597 |
| ABDFHGECA | 615 | | |