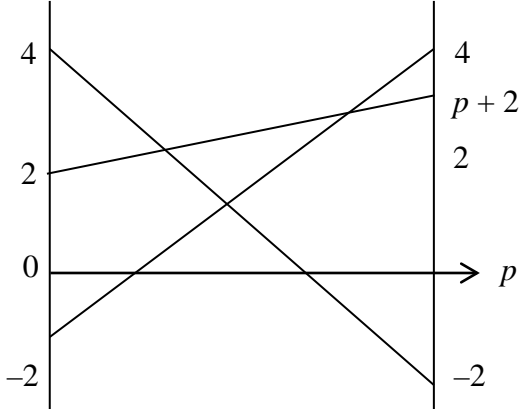
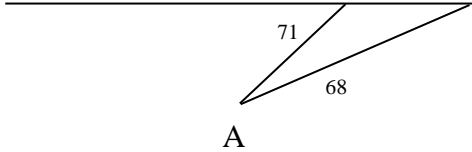


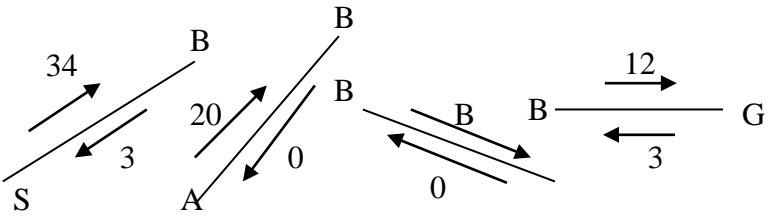
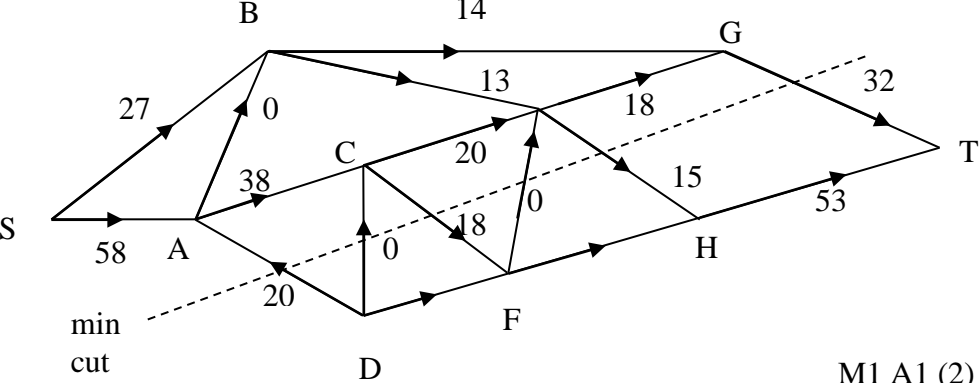
# Decision Mathematics D2 (6690)

## Mock paper mark scheme

Question number	Scheme	Marks																																																																																																																																																						
1.	<p>(a) Allocation is a1-1 algorithm. There are more machines than there are tasks.</p> <p>(b)</p> <table border="1" style="display: inline-table; margin-right: 20px;"> <tr><td>14</td><td>12</td><td>11</td><td>17</td><td>0</td></tr> <tr><td>14</td><td>13</td><td>15</td><td>16</td><td>0</td></tr> <tr><td>17</td><td>16</td><td>10</td><td>12</td><td>0</td></tr> <tr><td>16</td><td>14</td><td>13</td><td>12</td><td>0</td></tr> <tr><td>13</td><td>15</td><td>13</td><td>15</td><td>0</td></tr> </table> <p style="text-align: center;">→</p> <table border="1" style="display: inline-table; margin-right: 20px;"> <tr><td>4</td><td>6</td><td>7</td><td>1</td><td>18</td></tr> <tr><td>4</td><td>5</td><td>3</td><td>2</td><td>18</td></tr> <tr><td>1</td><td>2</td><td>8</td><td>6</td><td>18</td></tr> <tr><td>2</td><td>4</td><td>5</td><td>6</td><td>18</td></tr> <tr><td>5</td><td>3</td><td>5</td><td>3</td><td>18</td></tr> </table>  <table border="1" style="display: inline-table; margin-right: 20px;"> <tr><td>3</td><td>5</td><td>6</td><td>0</td><td>17</td></tr> <tr><td>2</td><td>3</td><td>1</td><td>0</td><td>16</td></tr> <tr><td>0</td><td>1</td><td>7</td><td>5</td><td>17</td></tr> <tr><td>0</td><td>2</td><td>3</td><td>4</td><td>16</td></tr> <tr><td>2</td><td>0</td><td>2</td><td>0</td><td>15</td></tr> </table> <p style="text-align: center;">→</p> <table border="1" style="display: inline-table; margin-right: 20px;"> <tr><td>3</td><td>5</td><td>5</td><td>0</td><td>2</td></tr> <tr><td>2</td><td>3</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>6</td><td>5</td><td>2</td></tr> <tr><td>0</td><td>2</td><td>2</td><td>4</td><td>1</td></tr> <tr><td>2</td><td>0</td><td>1</td><td>0</td><td>0</td></tr> </table>  <table border="1" style="display: inline-table; margin-right: 20px;"> <tr><td>4</td><td>5</td><td>5</td><td>0</td><td>2</td></tr> <tr><td>3</td><td>3</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>0</td><td>5</td><td>4</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>1</td><td>3</td><td>0</td></tr> <tr><td>3</td><td>0</td><td>1</td><td>0</td><td>0</td></tr> </table> <p style="text-align: center;"><i>or</i></p> <table border="1" style="display: inline-table; margin-right: 20px;"> <tr><td>3</td><td>4</td><td>4</td><td>0</td><td>1</td></tr> <tr><td>3</td><td>3</td><td>0</td><td>1</td><td>1</td></tr> <tr><td>0</td><td>0</td><td>5</td><td>5</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>1</td><td>4</td><td>0</td></tr> <tr><td>3</td><td>0</td><td>1</td><td>0</td><td>0</td></tr> </table> <p>A – 4 B – 3 C – 2 – 1 D – 1 – dummy E – dummy – 2</p>	14	12	11	17	0	14	13	15	16	0	17	16	10	12	0	16	14	13	12	0	13	15	13	15	0	4	6	7	1	18	4	5	3	2	18	1	2	8	6	18	2	4	5	6	18	5	3	5	3	18	3	5	6	0	17	2	3	1	0	16	0	1	7	5	17	0	2	3	4	16	2	0	2	0	15	3	5	5	0	2	2	3	0	0	1	0	1	6	5	2	0	2	2	4	1	2	0	1	0	0	4	5	5	0	2	3	3	0	0	1	0	0	5	4	1	0	1	1	3	0	3	0	1	0	0	3	4	4	0	1	3	3	0	1	1	0	0	5	5	1	0	1	1	4	0	3	0	1	0	0	<p>B2, 1, 0 (2)</p> <p>M1 A1</p> <p>M1 A1</p> <p>M1 A1 A1</p> <p>M1 A1 (9) <b>(11 marks)</b></p>
14	12	11	17	0																																																																																																																																																				
14	13	15	16	0																																																																																																																																																				
17	16	10	12	0																																																																																																																																																				
16	14	13	12	0																																																																																																																																																				
13	15	13	15	0																																																																																																																																																				
4	6	7	1	18																																																																																																																																																				
4	5	3	2	18																																																																																																																																																				
1	2	8	6	18																																																																																																																																																				
2	4	5	6	18																																																																																																																																																				
5	3	5	3	18																																																																																																																																																				
3	5	6	0	17																																																																																																																																																				
2	3	1	0	16																																																																																																																																																				
0	1	7	5	17																																																																																																																																																				
0	2	3	4	16																																																																																																																																																				
2	0	2	0	15																																																																																																																																																				
3	5	5	0	2																																																																																																																																																				
2	3	0	0	1																																																																																																																																																				
0	1	6	5	2																																																																																																																																																				
0	2	2	4	1																																																																																																																																																				
2	0	1	0	0																																																																																																																																																				
4	5	5	0	2																																																																																																																																																				
3	3	0	0	1																																																																																																																																																				
0	0	5	4	1																																																																																																																																																				
0	1	1	3	0																																																																																																																																																				
3	0	1	0	0																																																																																																																																																				
3	4	4	0	1																																																																																																																																																				
3	3	0	1	1																																																																																																																																																				
0	0	5	5	1																																																																																																																																																				
0	1	1	4	0																																																																																																																																																				
3	0	1	0	0																																																																																																																																																				

Question number	Scheme	Marks																		
2.	(a)																			
		$A = 0$ $P = 7$	M1 A1																	
		$B = 1$ $Q = 5$																		
		$C = 5$ $R = 4$																		
		$AR = 7 - 0 - 4 = 3$																		
		$BP = 5 - 1 - 7 = -3 \leftarrow$																		
		$CP = 14 - 5 - 7 = 2$																		
		$CC = 12 - 5 - 5 = 2$	A1																	
		<table border="1" style="display: inline-table; vertical-align: middle;"> <thead> <tr> <th></th> <th>P</th> <th>Q</th> <th>R</th> </tr> </thead> <tbody> <tr> <td>A</td> <td><math>10 - Q</math></td> <td><math>2 + Q</math></td> <td></td> </tr> <tr> <td>B</td> <td><math>Q</math></td> <td><math>7 - Q</math></td> <td></td> </tr> <tr> <td>C</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>		P	Q	R	A	$10 - Q$	$2 + Q$		B	$Q$	$7 - Q$		C				Entering cell BP Existing cell BQ $Q = 7$	M1 A1
		P	Q	R																
	A	$10 - Q$	$2 + Q$																	
B	$Q$	$7 - Q$																		
C																				
	<table border="1" style="display: inline-table; vertical-align: middle;"> <thead> <tr> <th></th> <th>P</th> <th>Q</th> <th>R</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>3</td> <td>9</td> <td></td> </tr> <tr> <td>B</td> <td>7</td> <td></td> <td>0</td> </tr> <tr> <td>C</td> <td></td> <td></td> <td>11</td> </tr> </tbody> </table>		P	Q	R	A	3	9		B	7		0	C			11		A1 (6)	
	P	Q	R																	
A	3	9																		
B	7		0																	
C			11																	
	(b)																			
		$A = 0$ $P = 7$																		
		$B = -2$ $Q = 5$																		
		$C = 2$ $R = 7$																		
		$AR = 7 - 0 - 7 = 0$																		
		$BQ = 6 + 2 - 5 = 3$																		
		$CP = 14 - 2 - 7 = 5$																		
		$CQ = 12 - 2 - 5 = 5$	B1																	
		All improvement inclines are non-negative, so optimal.	B1 (3)																	
			<b>(9 marks)</b>																	

Question number	Scheme	Marks
3.	<p>If B plays 1    A's expected gain = <math>4 - 6p</math></p> <p>If B plays 2    A's expected gain = <math>5p - 1</math></p> <p>If B plays 3    A's expected gain = <math>p + 2</math></p>  <p><math>4 - 6p = 5p - 1</math></p> <p><math>11p = 5</math></p> <p><math>p = \frac{5}{11}</math></p> <p>A should play 1 with probability <math>\frac{5}{11}</math></p> <p>and play 2 with probability <math>\frac{6}{11}</math>.</p> <p>The game has value <math>\frac{14}{11}</math> to A.</p>	<p>M1 A1</p> <p>M1 A1</p> <p>A1</p> <p>B1</p> <p>B1</p> <p><b>(7 marks)</b></p>
4.	<p>(a) A<sub>68</sub> D<sub>59</sub> F<sub>63</sub> C<sub>74</sub> B<sub>47</sub> E<sub>96</sub> A      407km</p> <p>(b) E    47    B    74    C    63    F    59    D</p>  <p>A</p> <p><math>243 + 68 + 71 = 382</math> km</p> <p>(c) <math>382 &lt; \text{optimal route} \leq 407</math></p>	<p>M1 A1 A1 (3)</p> <p>M1</p> <p>A1 A1 (3)</p> <p>M1 A1 (2)</p> <p><b>(8 marks)</b></p>

Question number	Scheme	Marks
5. (a)	$C_1 = 141$ $C_2 = 97$ Value of flow = 52	B1 B1 B1 (3)
(b)		M1 A1 (2)
(c)	E.g. SBEHT – 13 SACFHT – 7 SACEHT - 2 SBGECDFHT – 11	M1, A1 A1 A1 A1 (5)
(d)		M1 A1 (2)
(e)	Min cut = max flow = 85	M1 A1 (2) <b>(14 marks)</b>

Question number	Scheme	Marks																																														
6.	(a) $16x + 2y + 4z + r = 350$ $18x - 2y + 6z + s = 480$ $5x + 5z + t = 360$ $P - 18x - 7y - 20z = 0$	M1 A1 A2, 1, 0 (4)																																														
	(b)																																															
		<table border="1"> <thead> <tr> <th>bv</th> <th><math>x</math></th> <th><math>y</math></th> <th><math>z</math></th> <th><math>r</math></th> <th><math>s</math></th> <th><math>t</math></th> <th>value</th> </tr> </thead> <tbody> <tr> <td><math>r</math></td> <td>16</td> <td>2</td> <td>4</td> <td>1</td> <td>0</td> <td>0</td> <td>350</td> </tr> <tr> <td><math>s</math></td> <td>18</td> <td>-2</td> <td>6</td> <td>0</td> <td>1</td> <td>0</td> <td>480</td> </tr> <tr> <td><math>t</math></td> <td>5</td> <td>0</td> <td>5</td> <td>0</td> <td>0</td> <td>1</td> <td>360</td> </tr> <tr> <td><math>p</math></td> <td>-18</td> <td>-7</td> <td>-20</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	bv	$x$	$y$	$z$	$r$	$s$	$t$	value	$r$	16	2	4	1	0	0	350	$s$	18	-2	6	0	1	0	480	$t$	5	0	5	0	0	1	360	$p$	-18	-7	-20	0	0	0	0						
	bv	$x$	$y$	$z$	$r$	$s$	$t$	value																																								
	$r$	16	2	4	1	0	0	350																																								
	$s$	18	-2	6	0	1	0	480																																								
	$t$	5	0	5	0	0	1	360																																								
	$p$	-18	-7	-20	0	0	0	0																																								
		<table border="1"> <thead> <tr> <th>bv</th> <th><math>x</math></th> <th><math>y</math></th> <th><math>z</math></th> <th><math>r</math></th> <th><math>s</math></th> <th><math>t</math></th> <th>value</th> <th>row op</th> </tr> </thead> <tbody> <tr> <td><math>r</math></td> <td>12</td> <td>2</td> <td>0</td> <td>2</td> <td>0</td> <td><math>-\frac{4}{5}</math></td> <td>62</td> <td><math>R_1 - 4R_3</math></td> </tr> <tr> <td><math>s</math></td> <td>24</td> <td>-2</td> <td>0</td> <td>0</td> <td>1</td> <td><math>-\frac{6}{5}</math></td> <td>48</td> <td><math>R_2 - 6r_3</math></td> </tr> <tr> <td><math>z</math></td> <td>1</td> <td>0</td> <td>1</td> <td>0</td> <td>0</td> <td><math>\frac{1}{5}</math></td> <td>72</td> <td><math>R_3 \div 5</math></td> </tr> <tr> <td><math>p</math></td> <td>54</td> <td>-7</td> <td>0</td> <td>0</td> <td>0</td> <td>4</td> <td>1440</td> <td><math>R_4 + 20R_3</math></td> </tr> </tbody> </table>	bv	$x$	$y$	$z$	$r$	$s$	$t$	value	row op	$r$	12	2	0	2	0	$-\frac{4}{5}$	62	$R_1 - 4R_3$	$s$	24	-2	0	0	1	$-\frac{6}{5}$	48	$R_2 - 6r_3$	$z$	1	0	1	0	0	$\frac{1}{5}$	72	$R_3 \div 5$	$p$	54	-7	0	0	0	4	1440	$R_4 + 20R_3$	M1 A1 M1 A1 B1
	bv	$x$	$y$	$z$	$r$	$s$	$t$	value	row op																																							
$r$	12	2	0	2	0	$-\frac{4}{5}$	62	$R_1 - 4R_3$																																								
$s$	24	-2	0	0	1	$-\frac{6}{5}$	48	$R_2 - 6r_3$																																								
$z$	1	0	1	0	0	$\frac{1}{5}$	72	$R_3 \div 5$																																								
$p$	54	-7	0	0	0	4	1440	$R_4 + 20R_3$																																								
	<table border="1"> <thead> <tr> <th>bv</th> <th><math>x</math></th> <th><math>y</math></th> <th><math>z</math></th> <th><math>r</math></th> <th><math>s</math></th> <th><math>t</math></th> <th>value</th> <th>row op</th> </tr> </thead> <tbody> <tr> <td><math>y</math></td> <td>6</td> <td>1</td> <td>0</td> <td><math>\frac{1}{2}</math></td> <td>0</td> <td><math>-\frac{2}{5}</math></td> <td>31</td> <td><math>R_1 \div 2</math></td> </tr> <tr> <td><math>s</math></td> <td>24</td> <td>0</td> <td>0</td> <td>1</td> <td>1</td> <td>-2</td> <td>110</td> <td><math>R_2 + 2R_1</math></td> </tr> <tr> <td><math>z</math></td> <td>1</td> <td>0</td> <td>1</td> <td>0</td> <td>0</td> <td><math>\frac{1}{5}</math></td> <td>72</td> <td><math>R_3 \div 5</math></td> </tr> <tr> <td><math>p</math></td> <td>54</td> <td>0</td> <td>0</td> <td><math>\frac{7}{2}</math></td> <td>0</td> <td><math>-\frac{14}{5}</math></td> <td>217</td> <td><math>R_4 + 7R_1</math></td> </tr> </tbody> </table>	bv	$x$	$y$	$z$	$r$	$s$	$t$	value	row op	$y$	6	1	0	$\frac{1}{2}$	0	$-\frac{2}{5}$	31	$R_1 \div 2$	$s$	24	0	0	1	1	-2	110	$R_2 + 2R_1$	$z$	1	0	1	0	0	$\frac{1}{5}$	72	$R_3 \div 5$	$p$	54	0	0	$\frac{7}{2}$	0	$-\frac{14}{5}$	217	$R_4 + 7R_1$	M1 A1 M1 A1 (9)	
bv	$x$	$y$	$z$	$r$	$s$	$t$	value	row op																																								
$y$	6	1	0	$\frac{1}{2}$	0	$-\frac{2}{5}$	31	$R_1 \div 2$																																								
$s$	24	0	0	1	1	-2	110	$R_2 + 2R_1$																																								
$z$	1	0	1	0	0	$\frac{1}{5}$	72	$R_3 \div 5$																																								
$p$	54	0	0	$\frac{7}{2}$	0	$-\frac{14}{5}$	217	$R_4 + 7R_1$																																								
(c)	Not optimal since a negative value in the $p$ row	B1 (1)																																														

Question number	Scheme					Marks
						(14 marks)
7.			Act	Dest	value	
	May	0	4	0	500 +300 =800*	M1 A1 (2)
		1	3	0	500 +100=600*	
		2	2	0	500 +500=700*	
		3	1	0	500 +300=800*	
	April	1	4	0	500+300+100+800=1700*	M1 A1 A1 (3)
		2	4	1	500+300+200+600=1600	
			3	0	500 +200+600=1500*	
		3	4	2	500+300+300+700=1800	
			3	1	500 +300+600=1400*	
			2	0	500 +300+800=1600	
	March	1	4	3	500+300+100+1400=2300	M1 A1 A1 A1 (4)
			3	2	500 +100+1500=2100*	
			2	1	500 +100+1700=2300	
		2	3	3	500 +200+1400=2100*	
			2	2	500 +200+1500=2200	
			1	1	500 +200+1700=2400	
		3	2	3	500 +300+1400=2200	
			1	2	500 +300+1500=2300	
			0	1	+300+1700=2000*	
	Feb	0	4	2	500+300 +2100=2900	M1 A1
			3	1	500 +2100=2600	
		1	4	3	500+300+100+2000=2900	
3			2	500 +100+2100=2700*		
2			1	500 +100+2100=2700*		
Jan	0	4	1	500+300 +2700=3500	(3)	
		3	0	500 +2600=3100*		
	Jan	Feb	March	April	May	M1, A1 (2)
	3	3	3	3	4	
						(14 marks)

Question number	Scheme	Marks
	Cost £31.00	