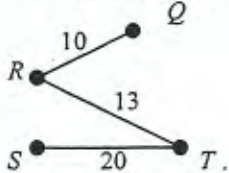
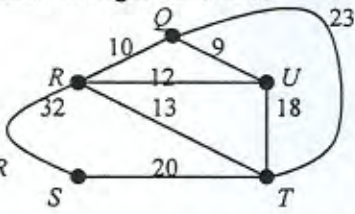


<p>1</p> <p>Original list    6   5   9   4   5   2</p> <p>After 1<sup>st</sup> pass    <u>5   6</u>   9   4   5   2</p> <p>After 2<sup>nd</sup> pass    <u>5   6   9</u>   4   5   2</p> <p>After 3<sup>rd</sup> pass    <u>4   5   6   9</u>   5   2</p> <p>After 4<sup>th</sup> pass    <u>4   5   5   6   9</u>   2</p> <p>After 5<sup>th</sup> pass    2   4   5   5   6   9</p> <p>May be shown vertically</p>	<p>M1</p> <p>M1</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>5</p>	<p>Decreasing order can score method marks only</p> <p>For 1<sup>st</sup> pass correct with shuttle sort</p> <p>For 2<sup>nd</sup> pass correct with shuttle sort or follow through from previous list</p> <p>For 3<sup>rd</sup> pass correct with shuttle sort or follow through from previous list</p> <p>For 4<sup>th</sup> pass correct with shuttle sort or follow through from previous list</p> <p>For final list from correct shuttle sort, with results at end of each pass clearly shown</p>
<p>2</p> <p>(i) Number of arcs <math>\times 2 =</math> sum of orders of vertices  <math>\Rightarrow (3+3+4+4+4+4) \div 2 = 11</math> arcs</p> <p>(ii) Semi-Eulerian, it has exactly two odd vertices</p> <p>(iii) Complete graph on five vertices has only 10 arcs, so 11 arcs means that all six vertices are connected.</p> <p>Or, a vertex of order 4 must join to four others so five vertices are connected. The sixth vertex has order at least three and cannot connect to itself so it must join to the other five.</p> <p>Or any equivalent reasoning.</p>	<p>M1</p> <p>A1</p> <p>B1</p> <p>B2</p> <p>5</p>	<p>For a general method</p> <p>For 11 calculated</p> <p>Drawing a specific case to get 11 scores B1 only</p> <p>For semi-Eulerian with a valid reason</p> <p>Accept 'two odd nodes' or 'two nodes of order 3' as minimal reasons</p> <p>For a good explanation of the general case by considering orders of vertices</p> <p>A weak explanation may score B1</p> <p>A diagram of a specific case is not sufficient</p>
<p>3</p> <p>(i) Minimum spanning tree with <math>U</math> removed</p>  <p><math>QR + RT + TS = 43</math> miles</p> <p>Join <math>U</math> back in using two shortest arcs</p> <p><math>43 + 9 + 12</math>  <math>= 64</math> miles</p> <p>(ii) Trying to apply nearest neighbour method</p>  <p>Start from <math>R</math></p> <p>to give <math>RQUTSR</math></p> <p><math>= 89</math> miles</p>	<p>M1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>A1</p> <p>7</p>	<p>For 43 or arcs <math>QR, RT, TS</math> or a convincing attempt to find minimum spanning tree for <math>\{Q, R, S, T\}</math></p> <p>For their <math>43 + 9 + 12</math></p> <p>cao (miles may be implied)</p> <p>For a correct start to an application of nearest neighbour with any start vertex, ie at least:  <math>QURTS, STRQU, TRQU</math> or <math>UQRTS</math></p> <p>For <math>R</math> as start vertex (may be implied from cycle)</p> <p>For <math>RQUTSR</math></p> <p>For 89 (miles may be implied) from valid method</p>

4

(i)

	1 <sup>st</sup>	3 <sup>rd</sup>	2 <sup>nd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	7 <sup>th</sup>	6 <sup>th</sup>	8 <sup>th</sup>
	A	B	C	D	E	F	G	H
A	-	4	2	3	-	-	-	-
B	4	-	1	-	3	-	-	-
C	2	1	-	2	-	6	5	-
D	3	-	2	-	-	-	4	-
E	-	3	-	-	-	8	-	7
F	-	-	6	-	8	-	-	8
G	-	-	5	4	-	-	-	9
H	-	-	-	-	7	8	9	-

Quickest time is at least 25 hours

M1

Answer should be on insert

M1

For starting by choosing row C in column A  
For choosing more than one entry from column C

A1

For a correct order (A), C, B, D, E, G, F, H

B1

For correct entries chosen or a correct tree drawn

B1

For 25  
Accept 'more than 25'

(ii)

M1

For a correct graph drawn

A1

For correct weights shown

(iii)

If AC is used then either B or D is excluded.  
Or must pass through C in getting between B and D, so AC is impossible.

B1

Follow through graph, if possible, provided same conclusion is valid

For explaining what happens if AC is used or why AC cannot be included.

(iv)

If EF is not used then passing through either E or F will take the team to H, the team will not be able to visit both E and F.

B1

Follow through graph, if possible, provided same conclusion is valid

For stating the effect of not using arc EF or for considering all possible routes into H

(v)

ABEFCDGH

ADGCB EFH

The second route is quicker (32 hours compared with 36 hours)

M1

Follow through graph, if possible

M1

For this route

A1

For this route

For identifying ADGCB EFH as the quicker or for calculating 32

12



5	<p>(i) <math>x \geq 0, y \geq 0</math>  <math>y \leq 2x + 1</math>  <math>4x + 3y \leq 12</math></p> <p>(ii) (0, 0), (3, 0), (0, 1)  (0.9, 2.8)  (0, 0) <math>\rightarrow P = 0</math>; (0, 1) <math>\rightarrow P = 3</math>;  (0.9, 2.8) <math>\rightarrow P = 12.9</math>; (3, 0) <math>\rightarrow P = 15</math>  <math>x = 3</math> and <math>y = 0</math>  <math>P = 15</math></p> <p>(iii) Either consider the gradient of the profit line  <math>(-\frac{1}{2}a)</math> and the gradients of the boundary lines  (2 and <math>-1\frac{1}{2}</math>)  or calculate <math>Q</math> at vertices <math>\Rightarrow 3, 0.9a+8.4, 3a</math>  Hence require <math>a \leq -6</math></p>	<p>B1  B1  B1</p> <p>B2  B1  M1</p> <p>A1  A1</p> <p>M1  M1  M1</p> <p>A1</p> <p>13</p>	<p>For both trivial constraints; allow <math>&gt;</math>  For this inequality, or equivalent; allow <math>&lt;</math>  For this inequality, or equivalent; allow <math>&lt;</math></p> <p>For these three vertices, any two correct <math>\Rightarrow</math> B1  For this vertex exact, in decimals or fractions  For calculating <math>P = 5x + 3y</math> for at least one of  their vertices or clear evidence of using an  appropriate line of constant profit  For the correct values of <math>x</math> and <math>y</math> clearly identified  For 15 clearly identified as the optimum value</p> <p>One method mark for each appropriate gradient  calculated correctly or for each appropriate value  of <math>Q</math> calculated correctly</p> <p>For the correct set of values identified  <math>[a = -6</math> or any valid proper subset of the correct  answer with no method shown <math>\Rightarrow</math> B1 only]</p>																																																																																																																
6	<p>(i) <math>5x + 3y - 5z + s = 15</math>  <math>2x + 6y + 8z + t = 24</math></p> <p>(ii)</p> <table> <tr> <th><math>P</math></th><th><math>x</math></th><th><math>y</math></th><th><math>z</math></th><th><math>s</math></th><th><math>t</math></th><th>-</th></tr> <tr> <td>1</td><td>-2</td><td>5</td><td>1</td><td>0</td><td>0</td><td>0</td></tr> <tr> <td>0</td><td>5</td><td>3</td><td>-5</td><td>1</td><td>0</td><td>15</td></tr> <tr> <td>0</td><td>2</td><td>6</td><td>8</td><td>0</td><td>1</td><td>24</td></tr> </table> <p>Pivot on 5 in <math>x</math> column</p> <table> <tr> <th><math>P</math></th><th><math>x</math></th><th><math>y</math></th><th><math>z</math></th><th><math>s</math></th><th><math>t</math></th><th>-</th></tr> <tr> <td>1</td><td>0</td><td>6.2</td><td>-1</td><td>0.4</td><td>0</td><td>6</td></tr> <tr> <td>0</td><td>1</td><td>0.6</td><td>-1</td><td>0.2</td><td>0</td><td>3</td></tr> <tr> <td>0</td><td>0</td><td>4.8</td><td>10</td><td>-0.4</td><td>1</td><td>18</td></tr> </table> <p>(iii)</p> <p>Pivot on 10 in <math>z</math> column</p> <table> <tr> <th><math>P</math></th><th><math>x</math></th><th><math>y</math></th><th><math>z</math></th><th><math>s</math></th><th><math>t</math></th><th>-</th></tr> <tr> <td>1</td><td>0</td><td>6.68</td><td>0</td><td>0.36</td><td>0.1</td><td>7.8</td></tr> <tr> <td>0</td><td>1</td><td>1.08</td><td>0</td><td>0.16</td><td>0.1</td><td>4.8</td></tr> <tr> <td>0</td><td>0</td><td>0.48</td><td>1</td><td>-0.04</td><td>0.1</td><td>1.8</td></tr> </table> <p><math>x = 4.8, y = 0, z = 1.8</math>  <math>P = 7.8</math></p> <p>(iv) We must now pivot on the 2 in the <math>x</math> column, this  gives</p> <table> <tr> <th><math>P</math></th><th><math>x</math></th><th><math>y</math></th><th><math>z</math></th><th><math>s</math></th><th><math>t</math></th><th>-</th></tr> <tr> <td>1</td><td>0</td><td>11</td><td>9</td><td>0</td><td>1</td><td>24</td></tr> <tr> <td>0</td><td>0</td><td>-12</td><td>-25</td><td>1</td><td>-2.5</td><td><math>k-60</math></td></tr> <tr> <td>0</td><td>1</td><td>3</td><td>4</td><td>0</td><td>0.5</td><td>12</td></tr> </table> <p>Hence <math>y = 0</math>  Accept 'no change to <math>y</math>'</p>	$P$	$x$	$y$	$z$	$s$	$t$	-	1	-2	5	1	0	0	0	0	5	3	-5	1	0	15	0	2	6	8	0	1	24	$P$	$x$	$y$	$z$	$s$	$t$	-	1	0	6.2	-1	0.4	0	6	0	1	0.6	-1	0.2	0	3	0	0	4.8	10	-0.4	1	18	$P$	$x$	$y$	$z$	$s$	$t$	-	1	0	6.68	0	0.36	0.1	7.8	0	1	1.08	0	0.16	0.1	4.8	0	0	0.48	1	-0.04	0.1	1.8	$P$	$x$	$y$	$z$	$s$	$t$	-	1	0	11	9	0	1	24	0	0	-12	-25	1	-2.5	$k-60$	0	1	3	4	0	0.5	12	<p>B1  B1</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>B1  B1</p> <p>M1</p> <p>A1</p> <p>13</p>	<p>For both equations correctly stated</p> <p>For <math>\pm(-2 \ 5 \ 1)</math> in objective row  Follow through from part (i)  For 5 3 -5 1 0 15 and 2 6 8 0 1 24  or equivalent in constraint rows</p> <p>For correct pivot choice for their tableau</p> <p>For a correct method for their table and their pivot  choice</p> <p>For increasing <math>P</math>  For correct tableau or equivalent, cao  ft their tableau provided not yet optimal</p> <p>For correct pivot choice</p> <p>For correct tableau or equivalent, cao</p> <p>For all three correct values for their final tableau</p> <p>For correct value for their final tableau</p> <p>For showing what happens to tableau,  only need to show enough to be able to deduce  answer (eg top row: 0 11 9 0 1 or <math>y</math> column)</p> <p>For correctly deducing <math>y = 0</math> in general case.</p> <p>Only using a specific value of <math>k</math> (eg <math>k = 60</math>) with  no general argument <math>\Rightarrow</math> M1, A0</p> <p>Do not imply method mark from statement '<math>y = 0</math>'  with no method seen.</p>
$P$	$x$	$y$	$z$	$s$	$t$	-																																																																																																													
1	-2	5	1	0	0	0																																																																																																													
0	5	3	-5	1	0	15																																																																																																													
0	2	6	8	0	1	24																																																																																																													
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1	0	6.2	-1	0.4	0	6																																																																																																													
0	1	0.6	-1	0.2	0	3																																																																																																													
0	0	4.8	10	-0.4	1	18																																																																																																													
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1	0	6.68	0	0.36	0.1	7.8																																																																																																													
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0	0	0.48	1	-0.04	0.1	1.8																																																																																																													
$P$	$x$	$y$	$z$	$s$	$t$	-																																																																																																													
1	0	11	9	0	1	24																																																																																																													
0	0	-12	-25	1	-2.5	$k-60$																																																																																																													
0	1	3	4	0	0.5	12																																																																																																													

7	(a)	(i)	A	<table border="1"><tr><td>1</td><td>0</td></tr><tr><td></td><td></td></tr></table>	1	0			B	<table border="1"><tr><td>2</td><td>2</td></tr><tr><td>2</td><td></td></tr></table>	2	2	2		M1	Answer should be on insert
1	0															
2	2															
2																
			C	<table border="1"><tr><td>3</td><td>4</td></tr><tr><td>4</td><td></td></tr></table>	3	4	4		D	<table border="1"><tr><td>4</td><td>7</td></tr><tr><td>8</td><td>7</td></tr></table>	4	7	8	7	A1	For correct temporary labels at D and E (condone extras here) For all temporary labels correct (with no extras)
3	4															
4																
4	7															
8	7															
			E	<table border="1"><tr><td>6</td><td>9</td></tr><tr><td>12</td><td>11 9</td></tr></table>	6	9	12	11 9	F	<table border="1"><tr><td>7</td><td>14</td></tr><tr><td>15</td><td>14</td></tr></table>	7	14	15	14	M1	For value 38 at J
6	9															
12	11 9															
7	14															
15	14															
			G	<table border="1"><tr><td>5</td><td>8</td></tr><tr><td>8</td><td></td></tr></table>	5	8	8		H	<table border="1"><tr><td>8</td><td>18</td></tr><tr><td>20</td><td>18</td></tr></table>	8	18	20	18	A1	For all permanent labels correct
5	8															
8																
8	18															
20	18															
			J	<table border="1"><tr><td>9</td><td>38</td></tr><tr><td>39</td><td>38</td></tr></table>	9	38	39	38			B1	For the correct order of assigning permanent labels: A, B, C, D, G, E, F, H, J				
9	38															
39	38															
			Shortest route: A - B - G - E					B1	For correct route and length.							
						Length = 900			Accept route reversed and accept length = 9							
			Shortest route: A - C - D - F - H - J					B1	For correct route and length.							
						Length = 3800			Accept route reversed and accept length = 38							
		(ii)	Length: 4700 metres					B1	Follow through from (i), if possible							
			E - G - B - A - C - D - F - H - J					B1	For 47 or 4700							
								M1	For E - G - B - A, or reversed, as part of a longer route							
								M1	For A - C - D - F - H - J, or reversed, as part of a longer route							
								A1	For whole route correct							
		(iii)	Explanation: G - B - A - C - D - F - H					M1	May be implied							
			E and J will be left out (either is sufficient)					A1	For identifying that route will not visit every vertex.							
		(b)	Odd nodes are A, C, D, E, F, G					M1	For trying to pair C, D, F, G (and no others)							
			Need to pair C, D, F, G in the shortest way					A1	For CD, FG or 10 (or 1000)							
			CD = 3 and FG = 7 ⇒ 10 (CF = 10, DG = 11 and CG = 8, DF = 7)					M1	For 147 (or 14700) or a good attempt seen or implied							
			Sum of all weights = 147					A1	For 15700 metres (or 15700 m or 157 hundred metres or 15.7 km). But 157 ⇒ M1, A0							
			Length = 15700 metres													

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