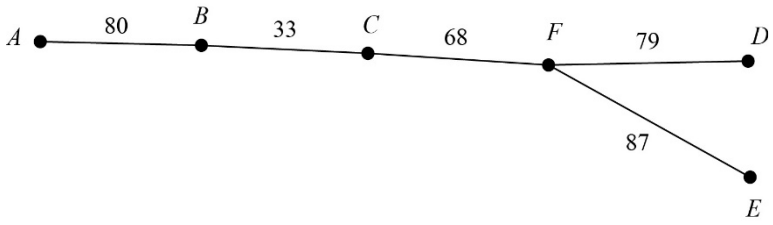
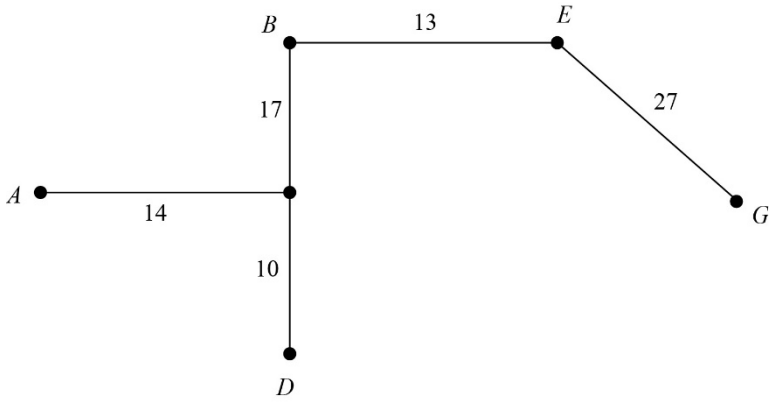
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
|---|---|---|---|---|
| **1a** | *AB BC CF DF EF* | **M1**<br>**M1** | 1.1b | 5th<br>Understand the travelling salesman problem |
| | Length 347 km | **A1** | | |
| | E.g.<br>  <br> | **A1** | | |
| | | **(4)** | | |
| **1bi** | Initial upper bound $= 2 \times 347 = 694$ km | **B1** | 1.1b | 5th<br>Understand the travelling salesman problem |
| | | **(1)** | | |
| **1bii** | Shortcut between *A* and *F* = 95. Saves 86 km.<br>and<br>Shortcut between *E* and *D* = 105. Saves 61 km | **M1**<br>**M1** | 3.1a | 5th<br>Understand the travelling salesman problem |
| | *ABCFDEFA* length 547 km | **A1** | | |
| | Either<br>*ABCFDEFCBA* length 633 km<br>or<br>*ABCFDFEFA* length 608 km | **M1**<br>**A1** | | |
| | | **(5)** | | |
| **1c** | Uses Prim's algorithm to find *AB* (80) *BC* (33) *AE* (103) *ED* (105) | **M1**<br>**M1** | 1.1b | 6th<br>Be able to find lower bounds for the travelling salesman problem |
| | 321 + 68 + 79 = 468 | **A1** | | |
| | | **(3)** | | |

| | | | | |
|---|---|---|---|---|
| **1d** | 468 km „ optimal solution „ 547 km | **B1**<br>**B1** | 2.2a | 7th<br>Know how to identify the best lower and upper bounds |
| | | **(2)** | | |
| | | | | **(15 marks)** |

**Notes**

**1b** **M1 AB BC CF** correct in order. **M2** All correct in order.

**1d** **M1 AB BC** in correct order. **M2** All correct order.

<table>
<tr><th>Q</th><th>Scheme</th><th>Marks</th><th>AOs</th><th>Pearson Progression Step and Progress Descriptor</th></tr>
<tr><td rowspan="5">2a</td><td> 
</td><td>M1</td><td rowspan="4">1.1b</td><td rowspan="4">7th<br>Know how to identify the best lower and upper bounds</td></tr>
<tr><td>Length = 81 km</td><td>A1</td></tr>
<tr><td>So lower bound 81 + 15 + 18 = 114 km</td><td>M1<br>A1</td></tr>
<tr><td>Best lower bound is 122 km</td><td>B1</td></tr>
<tr><td></td><td>(5)</td><td></td><td></td></tr>
<tr><td rowspan="2">2b</td><td><table>
<tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td></tr>
<tr><td>A</td><td>-</td><td>20</td><td>14</td><td>24</td><td>33</td><td>29</td><td>50</td></tr>
<tr><td>B</td><td>20</td><td>-</td><td>17</td><td>27</td><td>13</td><td>31</td><td>40</td></tr>
<tr><td>C</td><td>14</td><td>17</td><td>-</td><td>10</td><td>19</td><td>15</td><td>36</td></tr>
<tr><td>D</td><td>24</td><td>27</td><td>10</td><td>-</td><td>29</td><td>25</td><td>30</td></tr>
<tr><td>E</td><td>33</td><td>13</td><td>19</td><td>29</td><td>-</td><td>18</td><td>27</td></tr>
<tr><td>F</td><td>29</td><td>31</td><td>15</td><td>25</td><td>18</td><td>-</td><td>21</td></tr>
<tr><td>G</td><td>50</td><td>40</td><td>36</td><td>30</td><td>27</td><td>21</td><td>-</td></tr>
</table></td><td>B1<br>B1<br>B1</td><td rowspan="2">1.1b</td><td rowspan="2">5th<br>Understand the travelling salesman problem</td></tr>
<tr><td></td><td>(3)</td></tr>
<tr><td rowspan="3">2c</td><td>FCD(C)ABEGF</td><td>M1<br>A1</td><td rowspan="2">1.1b</td><td rowspan="2">5th<br>Use the nearest neighbour algorithm to find an upper bound</td></tr>
<tr><td>Length 130 km</td><td>A1</td></tr>
<tr><td></td><td>(3)</td><td></td><td></td></tr>
<tr><td colspan="5">(11 marks)</td></tr>
</table>

| Notes | |
|---|---|
| **2b** | **B1 DF** correct. **B1 AC** correct. **B1** all others correct. |
| **2c** | **M1**Tour, all vertices visited. |

| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
|---|---|---|---|---|
| **3a** | Two shortest arcs from depot A and E 11 + 12 = 23 | **M1**<br>**A1** | 3.1b | 8th<br>Solve the travelling salesman problem and interpret the solution in context |
| | 16 + 23 = 39 km | **A1** | | |
| | | **(3)** | | |
| **3b** | *PAEDBCFGP* | **M1**<br>**A1** | 1.1b | 8th<br>Solve the travelling salesman problem and interpret the solution in context |
| | Upper bound 47 km | **A1** | | |
| | | **(3)** | | |
| | | | | **(6 marks)** |

**Notes**

**3b** **M1** correctly uses spanning tree (*P*)*AEDBC*…..