

**AS and A level Further Mathematics Practice Paper – Route inspection problem**  
**Mark scheme**

Question	Scheme	Marks
<b>1(a)</b>	$BD + EF = 10 + 17 = 27$ $BE + DF = 15 + 10 = 25 \leftarrow$ $BF + DE = 20 + 14 = 34$ Repeat arcs BC, CE and DF Length of route = $129 + 25 = 154$	M1 A1 A1 A1 A1ft B1ft (6)
<b>1(b)</b>	We add BF(12) to the network so only have to repeat DE (14) Length of route is therefore $129 + 12 + 14 = 155$ $155 > 154$ so his route would be increased	M1 A1 (2)
		<b>(8 marks)</b>
<b>2(a)</b>	$D(A)E + F(J)K = 35 + 15 = 50^*$ $D(HJ)F + E(FJ)K = 24 + 40 = 64$ $D(HJ)K + EF = 33 + 25 = 58$ Arcs DA, AE, FJ, JK will be traversed twice Route length = $451 + 50 = 501$ (km)	M1 A1 (2 correct) A1 (3 correct) A1 A1ft (5)
<b>2(b)</b>	Vertex J would appear 3 times in the shortest inspection route	B1 (1)
<b>2(c)</b>	We only have to repeat one pair of odd vertices which does not include vertex K (DE = 35, DF = 24, EF = 25) DF is the smallest of the three so repeat DF (DH, HJ, JF) and therefore the other hut should be built at E Route e.g. EADEHDHJFBEFCGFJHLGKJLMK The length of the route is 475 (km)	DM1 A1 A1 A1ft (4)
		<b>(10 marks)</b>

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<p><b>3(a)</b></p>	<p>Shortest path A to H: ADCBEFJH Length of shortest path: 20 (miles)</p>	<p>M1 A1 (DCBE) A1 (FG) A1ft (JH)</p> <p>A1 A1ft <b>(6)</b></p>
<p><b>3(b)</b></p>	<p><math>AD + E(F)G = 5 + 5 = 10^*</math>  <math>A(DCB)E + D(CBEF)G = 12 + 12 = 24</math>  <math>A(DCBEF)G + D(CB)E = 17 + 7 = 24</math>                      Repeat edges: AD, EF, FG                      Length = <math>85 + 10 = 95</math> (miles)</p>	<p>M1 A1 A1</p> <p>A1 A1ft <b>(5)</b></p>
<p><b>3(c)</b></p>	<p>AD, CD, BC, BG                      Route: e.g. ADABCDCBFEHJFGBGA                      Length = <math>85 + 18 - 6 - 2 = 95</math> (miles)</p>	<p>B1 B1 M1 A1 <b>(4)</b></p>
		<p><b>(15 marks)</b></p>

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4(a)	$AF + GH = 15 + 31 = 46^*$ $AG + FH = 32 + 15 = 47$ $AH + FG = 30 + 17 = 47$ so repeat arcs AB, BF and GH	M1  A3,2,1.0 A1 (5)
4(b)	E.g. ABCDBFDEHGFHGFBA (17 nodes) length = $181 + 46 = 227$	B1 B1 ft (2)
4(c)	One path will have to be repeated. The shortest is 15 So repeat AF, use G and H as the start and finish. <b>or</b> repeat FH, use A and G as the start and finish.	M1 A1A1 (3)
		<b>(10 marks)</b>
5(a)	$AB + DE = 44 + 30 = 74^*$ $AD + BE = 42 + 35 = 77$ $AE + BD = 39 + 38 = 77$ Repeat arcs AC, BC and DE	M1  A3.2.1.0 A1 (5)
5(b)	E.g. ABCADCBEDFGDEGHECA (18 nodes) Length: $344 + 74 = 418$	B1 B1ft (2)
5(c)	One of AB (44), AD (42) or BD (38) will still have to be repeated. <b>BD(38) is the shortest</b> So start at E and <b>finish at A</b> , route length now is $344 + 38 = 382$	M1 A1 DA1 (3)
		<b>(10 marks)</b>

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<b>6(a)</b>	$AC + DF = 9 + 13 = 22 \leftarrow$ $AD + CF = 16 + 8 = 24$ $AF + CD = 17 + 7 = 24$ Repeat <b>arcs</b> AC, DG and GF	M1 A1 A1 A1 A1ft (5)
<b>6(b)</b>	E.g. ADCACGDGFGECBEFBA Length of route = $98 + 22 = 120$ (km)	B1 B1ft (2)
<b>6(c)</b>	CF (8) is the shortest link between 2 odd nodes excluding D Repeat CF (8) since this is the shortest path excluding D. We finish at A Length of route = $98 + 8 = 106$ (km)	M1 A1ft A1ft (3)
		<b>(10 marks)</b>
<b>7(a)</b>	AC (32) CF (14) DF (12) EF (17); BE (15) FI(18); IJ (10) GJ (9) DH (19)	M1 A1 A1 (3)
<b>7(b)</b>	$146 \times 80 = (\pounds) 11\ 680$	M1 A1 (2)
<b>7(c)</b>	$BF + GH = 32 + 40 = 72$ $BG + FH = 39 + 25 = 64^*$ $BH + FG = 57 + 37 = 94$ Roads BE, EG and FH need repeating	M1 A3,2,1,0 A1ft A1 (6)
<b>7(d)</b>	$379 + 64 = 443$ (km)	B1ft (1)
<b>7(e)</b>	Ben should choose to repeat FH (25) since this is the shortest. He should choose B and G as his start and finish vertices Route length is $379 + 25 = 404$ (km)	M1 A1 A1 (3)
		<b>(15 marks)</b>

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<b>Question</b>	<b>Scheme</b>	<b>Marks</b>
<b>8(a)</b>	$AD + FI = 4.5 + 5.3 = 9.8$ $AF + DI = 5.8 + 3.9 = 9.7$ smallest $AI + DF = 5.9 + 5.1 = 11.0$ e.g. ABDGIGDEIHFEACFEA	M1 A1 A1 A1 A1 (5)
<b>8(b)</b>	Roads AE, EF (or AEF), DG and GI (or DGI) should be repeated. Length is $31.6 + 9.7 = 41.3$ km We now only have to repeat one pair of odd vertices, one of which can not be D. (FI = 5.3, AF = 5.8 and AI = 5.9) FI gives the smallest of the three so choose to repeat FI (FHI) The machine should be collected from A.	B1 M1A1ft M1 A1 DA1 (3)
		<b>(11 marks)</b>
<b>9(a)</b>	$B(AD)E + F(J)H = 45 + 30 = 75^*$ $B(CK)F + E(DG)H = 50 + 35 = 85$ $B(CK)H + E(DGH)F = 60 + 65 = 125$ Arcs BA, AD, DE, FJ and JH will be transversed twice Route length = $384 + 75 = 459$ (meters)	M1 A1 (2 correct) A1 (3 correct) A1 A1 ft (5)
<b>9(b)</b>	e.g. if we start at an odd vertex we will finish at another odd vertex. This removes the need to repeat the route between them. So we just have to consider on repeated route rather than two	B2, 1, 0 (2)
<b>9(c)</b>	We only have to repeat one pair of odd vertices which does not include F (BE = 45, EH = 35, BH = 60) EH is the smallest of the repeat so repeat EH (ED, DG, GH) and therefore the guard should finish at B	M1 A1 (2)
<b>9(d)</b>	Route e.g. FJKFCKLJHGHEDGDECBDAB The length of the route is 419 (meters)	B1 B1ft (2)
		<b>(11 marks)</b>

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	<b>Source paper</b>	<b>Question number</b>	<b>New spec references</b>	<b>Question description</b>	<b>New AOs</b>
1	D1 Jan 2012	2	3.1	Route inspection problem	1.1b, 2.2a, 2.4
2	D1 2014	3	3.1	Route inspection	1.1b,3.1b
3	D1 2017	4	2.2, 3.1	Dijkstra, Route inspection problem	1.1b, 3.4
4	D1 2013R	5	3.1	Route inspection problem	1.1b, 2.2a, 2.4
5	D1 2013	5	3.1	Route inspection problem	1.1b, 2.2a, 2.4
6	D1 2011	5	3.1	Route inspection problem	1.1a, 1.1b, 2.2a, 2.4, 3.2a
7	D1 Jan 2013	5	2.1, 3.1	Prim and Kruskal, Route inspection problem	1.1b, 2.4
8	D1 Jan 2011	5	3.1	Route inspection problem	1.1b, 2.2a, 2.4
9	D1 2016	6	3.1	Route inspection problem	1.1b,2.2,2.4