

USING AND APPLYING DECISION MATHEMATICS
Unit 14

6994/2

For this paper you must have:

- an 8-page answer book;
- a clean copy of the Data Sheet (enclosed);
- a scientific calculator;
- a ruler;
- an insert for use in Questions 1,2,3 and 5 (enclosed).

Time allowed: 1 hour 30 minutes

Instructions

- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book.
- The *Examining Body* for this paper is AQA. The *Paper Reference* is 699X
- Answer **all** questions.
- All necessary working should be shown; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should normally be given to three significant figures.
- You may **not** refer to the copy of the Data Sheet that was available prior to this examination. A clean copy is available for your use.
- Fill in the boxes at the top of the insert. Make sure you attach the insert to your answer book.

Information

- The maximum mark for this paper is 60.
- Mark allocations are shown in brackets.

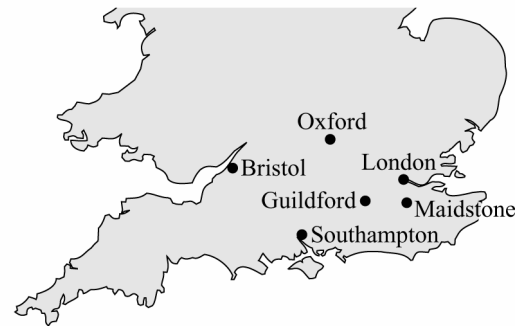
SECTION A

Answer **all** questions.Use **Distances and Journey Times** on page 2 of the Data Sheet.

Some of the data are reproduced below. *Figure 1, printed on the insert, is provided for use in Question 1.*

- 1 A salesperson has to make a tour of six towns, before returning to his starting town. The distances (in miles) are shown below.

Distances in Miles		B	G	L	M	O	S
Bristol	B	—	106	120	167	73	106
Guildford	G	106	—	31	58	67	49
London	L	120	31	—	39	56	77
Maidstone	M	167	58	39	—	107	113
Oxford	O	73	67	56	107	—	67
Southampton	S	106	49	77	113	67	—



- (a) Find the lengths of the tours obtained by using the nearest neighbour algorithm starting from:
- (i) Bristol (3 marks)
- (ii) London (3 marks)
- (b) (i) By deleting L, find a lower bound for the length of a minimum tour. (3 marks)
- (ii) By deleting B, find another lower bound. (3 marks)

- (c) The length of a minimum tour is T kilometres.

Write down the smallest interval for T which can be obtained from your answers to parts (a) and (b). *(2 marks)*

- (d) Use the map of Southern England to suggest an improved tour to that of part (a). Find its length. *(2 marks)*

2 **Figure 2**, printed on the insert, is provided for use in Question 2.

A local newspaper commissions an experienced driver to check the off-peak driving times along some of the AA-recommended routes connecting Birmingham, Cardiff, Carmarthen, Gloucester and Hereford.

- (a) On Figure 2 of the insert, complete the network of journey times. *(2 marks)*
- (b) Find the total of all the times on the network. *(1 mark)*
- (c) Explain why the driver will need to drive more than is indicated by the answer to part (b). *(1 mark)*
- (d) Showing all your working, find the minimum driving time the driver can expect to take to complete his task. *(5 marks)*
- (e) Suggest a possible route for the driver, starting and finishing in Carmarthen, that corresponds to the minimum time. *(2 marks)*
- (f) State **two** reasons why the times taken by the driver may differ from those given by the AA. *(3 marks)*

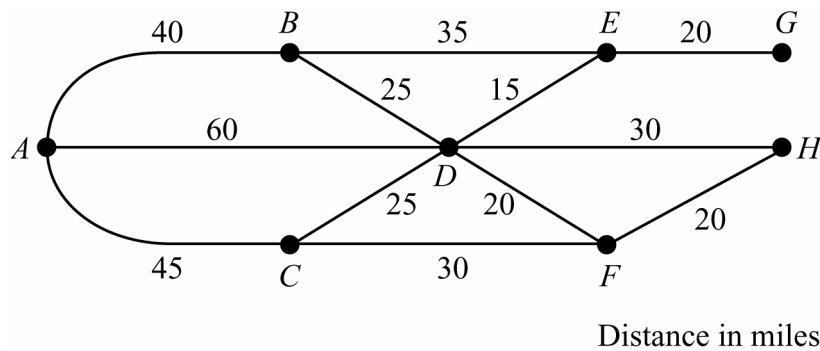
Turn over for the next question

SECTION B

Answer **all** questions.

Use **Pipelines** on page 3 of the Data Sheet.

- 3 The relevant parts of the data are reproduced below. Figure 3, printed on the insert, is provided for use in Question 3.



- (a) On **Figure 3** of the insert, complete the matrix that represents the pipelines connecting A, B, C, D, E, F, G and H. (2 marks)
- (b) Apply Prim's algorithm to your matrix, starting by crossing out row A, to find a minimum connector and its total length. Show all your working clearly, and indicate the order in which you build up your minimum connector. (5 marks)
- (c) Draw a tree representing your minimum connector. (2 marks)
- (d) Using only the pipelines of your minimum connector, what is the maximum distance between two points on the network? (2 marks)
- (e) Suggest why the actual pipe network consists of more pipelines than those on the minimum connector. (2 marks)
- (f) State **two** features of an actual pipe network which are **not** represented on the network shown above. (2 marks)

SECTION C

Answer **all** questions.

- 4 The owners of a holiday resort intend to improve wheelchair access. The costs (in £1000's) of installing lifts or ramps to connect different parts of the resort are shown in the table. X means that a direct connection is impractical.

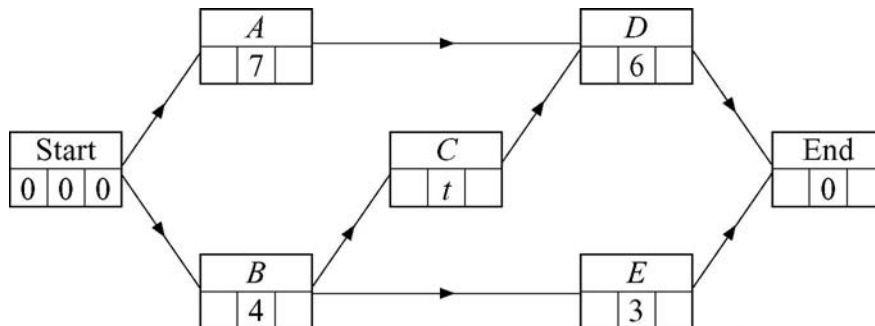
	Reception	A	B	C	D	E
Reception	–	6	4	7	X	X
A	6	–	1	5	7	3
B	4	1	–	X	9	X
C	7	5	X	–	5	4
D	X	7	9	5	–	3
E	X	3	X	4	3	–

- (a) Draw a network to represent the data in the table. *(3 marks)*
- (b) Apply Dijkstra's algorithm to find the cheapest cost of making D accessible from the Reception and give the route corresponding to the minimum cost. Show your working clearly and indicate the order in which you assign permanent labels. *(6 marks)*

Turn over for the next question

5 **Figure 4**, printed on the insert, is provided for use in Question 5.

A small construction project has an activity network as shown.



- (a) On figure 4 of the insert, complete the early and late times for the network when the duration of activity C is $t = 2$. (4 marks)
- (b) For what range of values of t is activity C critical? (2 marks)

END OF QUESTIONS

Free-Standing Mathematics Qualification
Specimen Unit
Advanced Level



USING AND APPLYING DECISION MATHEMATICS
Unit 14

6994/2PM

PRELIMINARY MATERIAL

DATA SHEET

REMINDER TO CANDIDATES

**YOU MUST NOT BRING THIS DATA SHEET
WITH YOU WHEN YOU SIT THE EXAMINATION.
A CLEAN COPY WILL BE MADE AVAILABLE.**

Distances and journey times



The mileage chart opposite shows distances in miles between two towns along AA-recommended routes. Using motorways and other main roads this is normally the fastest route, though not necessarily the shortest.

The journey times, shown in hours and minutes, are average off-peak driving times along AA-recommended routes. These times should be used as a guide only and do not allow for unforeseen traffic delays, rest breaks or fuel stops.

For example, the 378 mile (608 km) journey between Glasgow and Norwich should take approximately 7 hours 28 minutes.

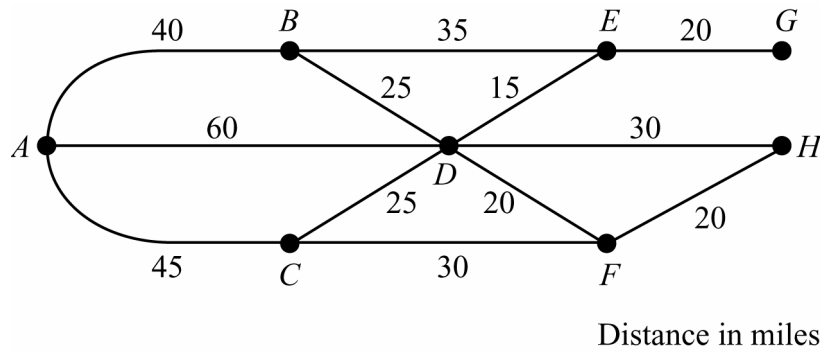
Journey Times

Aberdeen	906	1052	750	1051	913	907	936	426	1020	1047	1108	236	1027	357	301	836	1007	850	843	735	240	517	655	753	636	1029	632	545	510	840	1007	757	907	1246	151	837	1114	1039	558	1009	721	747	1024	703	505	990	513	643	955
Aberystwyth	436	249	538	301	431	229	444	115	432	612	647	412	901	624	251	443	158	234	436	959	359	345	430	244	533	304	456	527	340	554	339	354	631	720	419	459	455	317	412	350	154	439	252	713	335	1231	410	455	
Barnstaple	326	423	200	501	234	629	335	206	513	832	115	1047	810	227	339	303	636	547	1144	542	509	507	456	434	448	628	700	409	624	422	319	233	906	452	145	324	503	232	500	403	307	400	858	109	1417	543	403		
Birmingham	310	147	154	210	327	311	321	334	530	301	745	507	110	226	125	334	233	842	242	216	157	153	255	146	315	346	102	316	108	126	500	604	142	348	258	200	243	146	101	243	058	556	224	1115	229	217			
Brighton	301	213	336	628	436	232	154	831	351	1045	808	301	102	348	635	451	1143	543	436	353	454	116	447	535	606	223	320	329	200	610	905	248	438	109	501	151	406	402	127	359	857	319	1416	449	218				
Bristol	315	059	451	159	144	337	654	134	908	631	048	206	124	457	408	1005	405	351	328	317	258	310	450	521	224	439	243	134	353	727	313	217	217	324	128	321	224	202	221	720	057	1238	404	218					
Cardiff	347	448	448	345	210	637	438	906	628	247	200	302	516	248	1003	422	242	149	336	131	319	335	407	112	135	144	201	657	721	044	525	252	342	254	221	243	244	240	717	401	1236	250	129						
Cardistie	514	116	230	413	717	210	931	654	117	241	117	455	431	1029	429	414	351	340	334	333	513	544	257	511	307	210	429	751	337	257	253	347	210	345	239	237	245	743	133	1302	428	254							
Carmarthen	558	625	649	207	605	422	145	414	545	428	421	316	519	056	237	334	214	610	210	200	125	418	549	338	445	824	241	418	652	618	136	547	300	326	602	241	233	528	752	225	533								
Dorchester	330	513	756	310	1011	734	217	341	200	349	531	1108	528	454	451	399	434	414	605	637	357	611	407	310	529	830	436	357	353	427	310	444	249	337	344	822	233	1341	520	354									
Dover	242	828	132	311	805	222	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268	268		
Edinburgh	838	445	1106	829	337	145	424	656	449	1204	604	442	300	515	046	508	536	607	241	318	345	236	704	922	245	532	238	522	254	422	423	244	420	918	411	1436	450	145											
Exeter	807	311	057	616	747	630	623	505	332	257	426	523	416	759	412	315	240	620	738	527	647	1026	049	607	854	819	338	749	455	527	804	442	301	730	605	414	735												
Fort William	1022	745	202	311	238	611	522	1119	519	504	442	431	406	423	603	635	344	599	357	254	225	841	427	057	254	438	203	435	338	237	335	833	044	1352	518	738													
Glasgow	242	831	1002	845	838	733	140	512	653	751	631	1027	627	615	541	835	1005	754	902	1241	234	835	1034	502	1004	716	625	1004	115	588	832	757	316	727	440	506	742	421	207	708	625	404	713						
Gloucester	208	051	420	331	928	328	314	251	240	258	232	413	444	155	410	205	110	421	650	236	249	219	247	147	244	147	204	144	643	125	1201	327	217																
Guildford	254	551	1010	959	459	332	314	410	106	405	521	523	139	310	245	116	530	821	210	398	098	418	120	323	318	106	315	813	239	1332	406	052																	
Hereford	353	345	943	343	328	305	254	345	247	427	458	211	425	221	156	457	704	251	325	306	343	219	152	159	654	201	1332	1357	411	303																			
Holyhead	412	935	335	321	426	221	617	241	432	503	424	638	351	451	830	657	457	658	623	254	553	327	239	608	247	649	534	1208	347	539																			
Hull	831	245	109	105	217	410	148	200	234	239	332	143	326	740	549	219	608	458	209	447	115	312	443	233	545	444	1103	058	349																				
Inverness	605	751	848	728	1124	724	642	607	932	1102	852	959	1338	243	922	1305	1131	650	1101	814	840	1116	755	556	1042	237	738	1047																					
Kendal	158	308	129	536	125	148	205	333	520	300	400	739	332	605	302	400	219	529	407	228	359	108	242	355	200	603	405	1122	136	250																			
Leeds	129	124	405	054	124	155	223	349	127	310	722	510	213	550	442	116	431	048	224	427	139	506	426	1024	040	338																							
Lincoln	236	311	205	221	253	151	227	057	238	701	607	117	529	407	228	359	108	242	355	200	603	405	1122	136	250																								
Liverpool	437	046	237	308	244	450	211	311	650	450	317	518	444	047	413	142	137	428	107	443	354	1001	152	359																									
Maidstone	429	457	528	201	239	306	157	625	843	206	653	159	443	215	343	343	205	341	839	332	1357	411	106																										
Manchester	208	239	236	419	146	304	642	446	249	510	436	045	405	106	144	420	059	439	346	957	122	352																											
Middlesbrough	048	321	436	225	408	822	359	306	650	540	226	529	153	338	525	253	429	526	914	109	436																												
Newcastle	351	506	236	438	853	336	721	611	244	559	223	408	555	323	354	557	839	142	506																														
Norhampton	234	114	058	604	653	100	432	231	050	502	219	152	150	215	147	646	308	1204	235	123																													
Norwich	253	324	820	823	154	648	400	444	413	324	406	403	355	820	524	1338	352	245																															
Nottingham	201	615	611	115	443	333	218	322	056	151	318	108	607	319	1125	139	229																																
Nottingham	1100	646	148	514	657	423	654	557	457	554	1053	303	1611	737	558																																		
Oxford	652	928	853	412	823	535	601	838	517	318	804	516	458	809																																			
Penzance	514	303	313	306	152	232	255	214	648	350	1206	221	146																																				
Perth	341	525	250	522	425	324	422	920	131	1439	605	425																																					
Peterborough	450	054	410	350	030	347	846	222	1404	433	145																																						
Plymouth	420	134	159	435	114	405	401	923	144	406																																							
Portsmouth	359	320	037	317	816	130	1334	442	150																																								
Preston	224	356	124	529	357	1047	107	307																																									
Salisbury	335	102	554	301	1112	251	306																																										
Sheffield	332	830	205	1349	437	140																																											
Shrewsbury	509	258	1028	206	302																																												
Southampton	757	825	453	802																																													
Stoke-on-Trent	1315	441	301																																														
Stranraer	1011	1320																																															
Taunton	352																																																
Wick																																																	
York																																																	
LONDON																																																	

Distances in miles (one mile equals 1.6093km)

Pipelines

The lengths of pipelines between various pumping stations are as shown.



USING AND APPLYING DECISION MATHEMATICS
Unit 14

Insert for use in Questions 1, 2, 3 and 5.

Figure 1

Distances in Miles		B	G	L	M	O	S
Bristol	B	–	106	120	167	73	106
Guildford	G	106	–	31	58	67	49
London	L	120	31	–	39	56	77
Maidstone	M	167	58	39	–	107	113
Oxford	O	73	67	56	107	–	67
Southampton	S	106	49	77	113	67	–

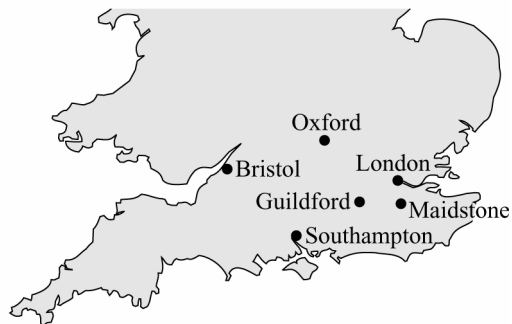
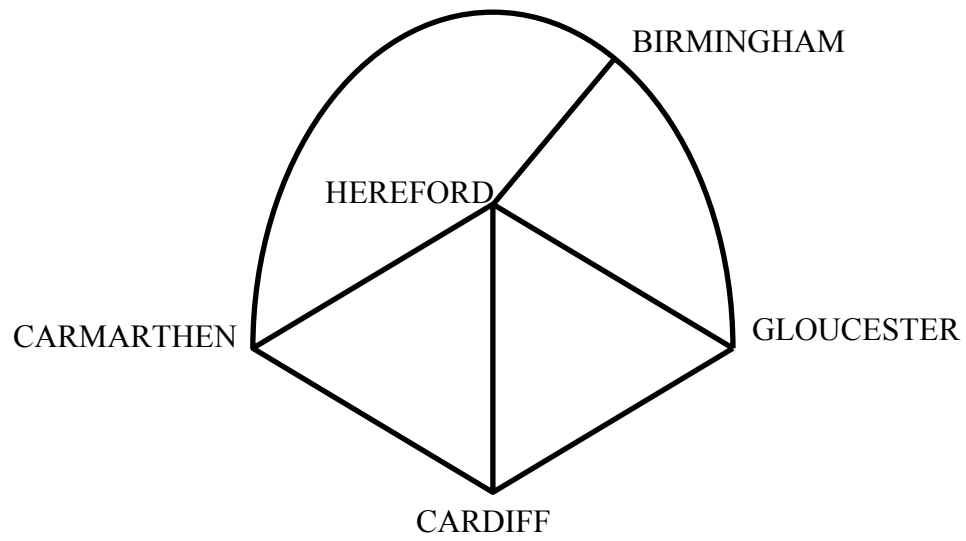
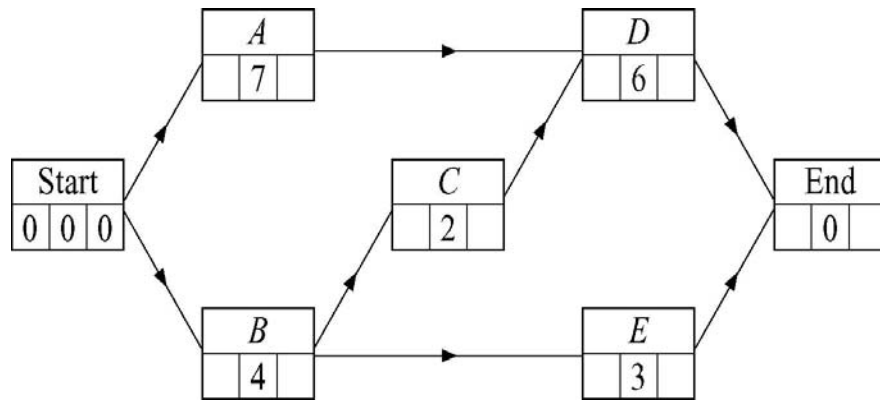


Figure 2**Figure 3**

	A	B	C	D	E	F	G	H
A								
B								
C								
D								
E								
F								
G								
H								

Figure 4



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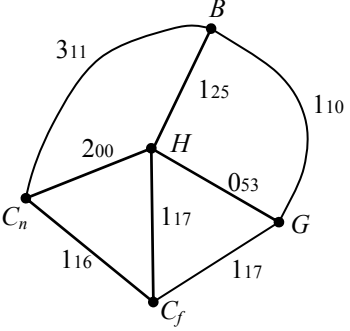
Free-Standing Mathematics Qualification

Using and Applying Decision Mathematics

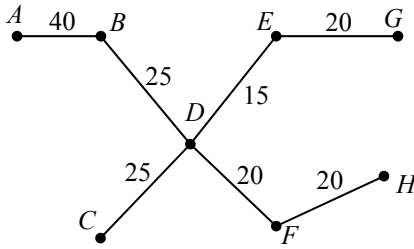
Question 1

(a)(i)	$B_{73} O_{56} L_{31} G_{49} S_{113} M_{167} B$ 489 miles	B1 M1 A1	B-0 Visits all vertices
(ii)	$L_{31} G_{49} S_{67} O_{73} B_{167} M_{39} L$ 426 miles	B1 M1 A1	L-G Visits all vertices
(b)(i)	$L < \begin{matrix} 31 \\ 39 \end{matrix}$ $M_{58} G_{49} S_{67} O_{73} B$ 317 miles	B1 M1 A1	Can be implied MST with 4 edges
(b)(ii)	$B < \begin{matrix} 73 \\ 106 \end{matrix}$ $O_{56} L_{31} G_{49} S$ M_{39} 354 miles	B1 M1 A1	
(c)	$354 \leq T \leq 426$	B1F,BIF	FT on answers to (a) and (b)
(d)	$B_{73} O_{56} L_{39} M_{58} G_{49} S_{106} B$ 381 miles	M1 A1	Any tour Improving on (a)
	TOTAL	16	

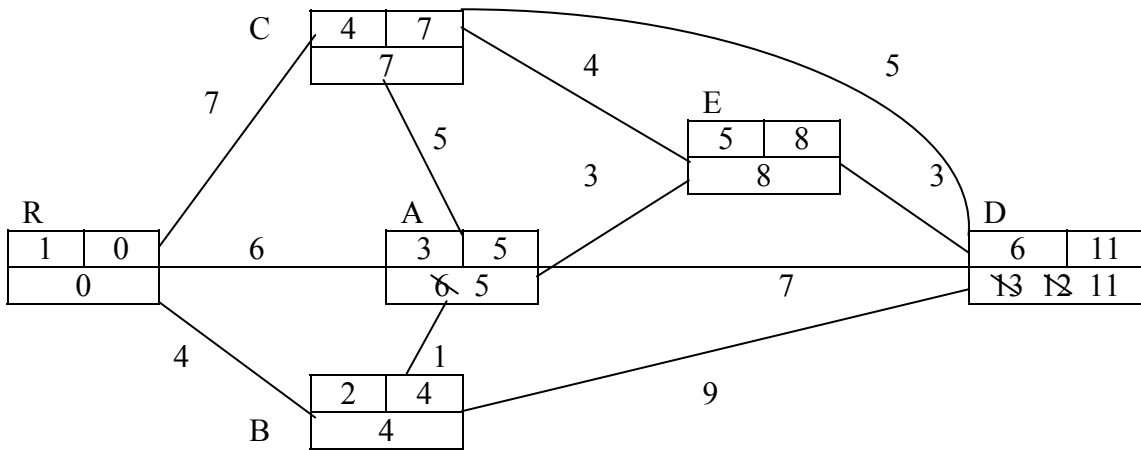
Question 2

(a)			
(b)	12 hours 29 minutes	B1	
(c)	There are odd nodes so an Eulerian trail is impossible	B1	
(d)	$B - C_n, C_f - G \quad 4+$ $B - G, C_f - C_n \quad 2_{26}$ $B - C_f, C - C_G \quad 4+$ The least pairing is $B - G, C_f - C_n$ $12_{29} + 2_{26} = 14_{55}$	M1 A1 M1 M1 A1	One pair considered All three
(e)	E.g. $C_n H B G H C_f G B C_n C_f C_n$	M1 A1	
(f)	E.g. Traffic delays The AA times are only averages	B2 B1	1st reason 2nd reason
Total		14	

Question 3

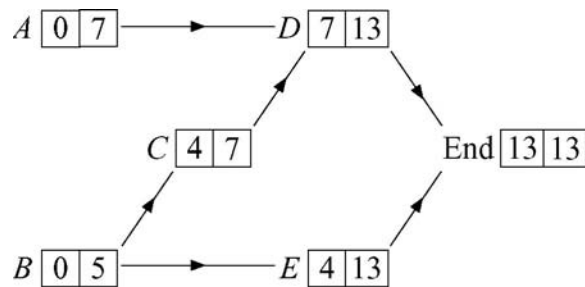
(a)	<table border="1"> <thead> <tr> <th></th> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>F</th> <th>G</th> <th>H</th> </tr> </thead> <tbody> <tr> <th>A</th> <td>/</td> <td>40</td> <td>45</td> <td>60</td> <td>/</td> <td>/</td> <td>/</td> <td>/</td> </tr> <tr> <th>B</th> <td>40</td> <td>/</td> <td>/</td> <td>25</td> <td>35</td> <td>/</td> <td>/</td> <td>/</td> </tr> <tr> <th>C</th> <td>45</td> <td>/</td> <td>/</td> <td>25</td> <td>/</td> <td>30</td> <td>/</td> <td>/</td> </tr> <tr> <th>D</th> <td>60</td> <td>25</td> <td>25</td> <td>/</td> <td>15</td> <td>20</td> <td>/</td> <td>30</td> </tr> <tr> <th>E</th> <td>/</td> <td>35</td> <td>/</td> <td>15</td> <td>/</td> <td>/</td> <td>20</td> <td>/</td> </tr> <tr> <th>F</th> <td>/</td> <td>/</td> <td>30</td> <td>20</td> <td>/</td> <td>/</td> <td>/</td> <td>/</td> </tr> <tr> <th>G</th> <td>/</td> <td>/</td> <td>/</td> <td>/</td> <td>20</td> <td>/</td> <td>/</td> <td>/</td> </tr> <tr> <th>H</th> <td>/</td> <td>/</td> <td>/</td> <td>30</td> <td>/</td> <td>20</td> <td>/</td> <td>/</td> </tr> </tbody> </table>		A	B	C	D	E	F	G	H	A	/	40	45	60	/	/	/	/	B	40	/	/	25	35	/	/	/	C	45	/	/	25	/	30	/	/	D	60	25	25	/	15	20	/	30	E	/	35	/	15	/	/	20	/	F	/	/	30	20	/	/	/	/	G	/	/	/	/	20	/	/	/	H	/	/	/	30	/	20	/	/	M1 A1	
	A	B	C	D	E	F	G	H																																																																												
A	/	40	45	60	/	/	/	/																																																																												
B	40	/	/	25	35	/	/	/																																																																												
C	45	/	/	25	/	30	/	/																																																																												
D	60	25	25	/	15	20	/	30																																																																												
E	/	35	/	15	/	/	20	/																																																																												
F	/	/	30	20	/	/	/	/																																																																												
G	/	/	/	/	20	/	/	/																																																																												
H	/	/	/	30	/	20	/	/																																																																												
(b)	<p>Clear method AB 40 BD 25 DE 15 DF 20, EG 20, FH 20 CD 25 165 miles</p>	M1 A1 B1 M1 A1	SC B2 no working																																																																																	
(c)		M1 A1																																																																																		
(d)	105 miles (AH)	M1A1																																																																																		
(e)	<p>Answers relating to either:- Increasing the capacity of the network Or Maintaining flow when pipelines are either damaged or being maintained</p>	B2																																																																																		
(f)	E.g. Direction of flow Capacities	B1 B1																																																																																		
	Total	15																																																																																		

Question 4



(a)	Networks	M1 A1	
	Costs	A1	
(b)	Evidence of Dijkstra Correct at B and C	M1 A1	6 ft on route
	Correct at A and D	M1 A1	
	R B A E D £11,000	B1 B1F	
	Total	9	

Question 5



(a)	Early times All correct Late times	M1 A1 M1	at least 4 correct
	All correct	A1	at least 4 correct, following through from the final early time
(b)	'3' obtained $t \geq 3$	B1 B1	
	Total	6	