

Centre Number						Candidate Number				
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Other Names										
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	



Free-Standing Mathematics Qualification
Advanced Level
June 2011

Using and Applying Decision Mathematics

6994/2

Unit 14

Thursday 19 May 2011 1.30 pm to 3.00 pm

For this paper you must have:

- a clean copy of the Data Sheet (enclosed)
- a calculator
- a ruler.

Time allowed

- 1 hour 30 minutes

Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer the questions in the spaces provided. Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- You may **not** refer to the copy of the Data Sheet that was available prior to this examination. A clean copy is enclosed for your use.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 60.
- You may use either a scientific calculator or a graphics calculator.



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Section A

Answer **all** questions in the spaces provided.

Use **Renovating a house** on page 2 of the Data Sheet.

- 1** A house has been bought at auction and needs to be completely renovated.

The work involved has been divided into a number of tasks, as shown in the table. The minimum time required to complete each task is also shown.

Activity	Immediate predecessor	Duration (days)
A: Remove plaster	–	3
B: Remove bathroom and kitchen fittings	–	1
C: Take out windows	–	1
D: Remove tiles from roof	–	1
E: Install new damp-proof course	A	1
F: Remove wiring and plumbing	A, B	2
G: First-fix wiring and plumbing	F	4
H: Fit new windows	C	2
I: Fit roof tiles	D	3
J: Plaster walls and ceilings	E, G, H, I	6
K: Fit new bathroom and kitchen	J	3
L: Second-fix wiring and plumbing	J	2
M: Tile kitchen and bathroom	K, L	2

- (a) Construct an activity network for the project. (4 marks)
- (b) Find the earliest start time for each activity. (2 marks)
- (c) Find the latest finish time for each activity. (4 marks)
- (d) State the critical path. (1 mark)
- (e) State the float time for activity B and the float time for activity I. (2 marks)
- (f) Using the grid **on page 5**, draw a cascade (Gantt) diagram for the project. (4 marks)
- (g) Bad weather means that work on removing the roof tiles can start only when the project has already been going for 7 days. Find the new minimum completion time for the project. (2 marks)

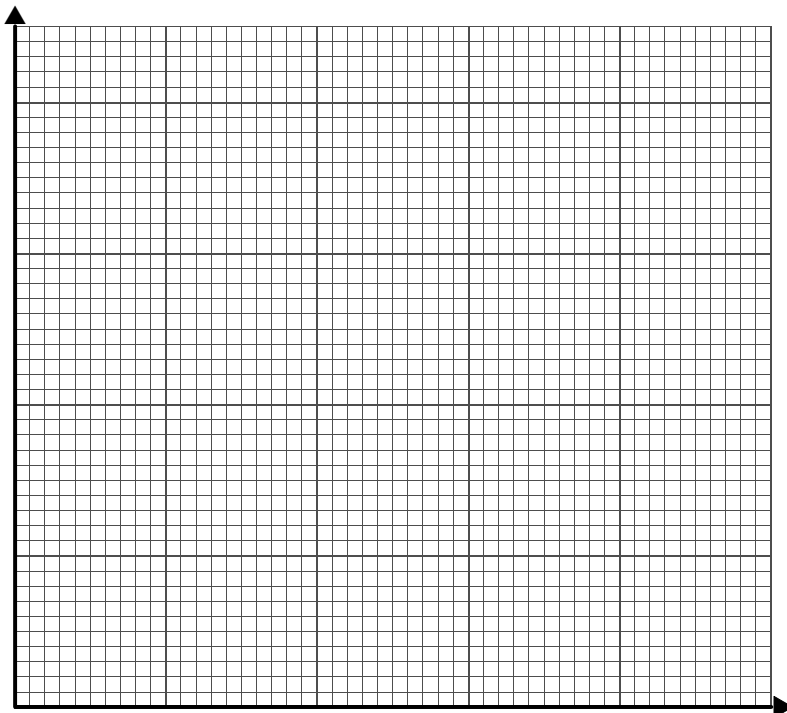


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Section B

Answer **all** questions in the spaces provided.

Use **Oil company** on page 3 of the Data Sheet.

- 2** An oil company has oil rigs based in the North Sea and an oil terminal, T, on shore. Oil is to be pumped to the terminal through a network of pipes. Oil can also be pumped from one rig to another. Oil rigs at I, J and K, mentioned on the Data Sheet, are **not** included in this network.

The table shows the distances, in miles, between pairs of rigs, and the distance of each rig from the terminal.

The company intends to build the pipes in such a way as to minimise their total length.

	T	A	B	C	D	E	F	G	H
T	–	70	86	96	90	82	74	80	90
A	70	–	60	40	48	70	44	56	75
B	86	60	–	60	56	60	70	66	60
C	96	40	60	–	44	40	48	56	36
D	90	48	56	44	–	45	48	56	48
E	82	70	60	40	45	–	52	60	56
F	74	44	70	48	48	52	–	56	32
G	80	56	66	56	56	60	56	–	52
H	90	75	60	36	48	56	32	52	–

- (a) Showing the order in which you select the edges, use Prim's algorithm, starting from T, to find a minimum spanning tree for the entire system. (5 marks)
- (b) State the length of your minimum spanning tree for the entire system. (1 mark)
- (c) Draw your minimum spanning tree. (2 marks)
- (d) If Kruskal's algorithm had been used, the same minimum spanning tree would have been obtained. State which would have been the fifth edge and the sixth edge to be added to the tree using this method. (2 marks)
- (e) Before any pipes have been laid, the company decides not to include the rig at D and its potential pipework connections. Find the length of the minimum spanning tree for the remaining 7 rigs and terminal. (2 marks)



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Section C

Answer **all** questions in the spaces provided.

Use **Humberside** on page 4 of the Data Sheet.

3 The diagram opposite shows the locations of some places in North Humberside. The number on each edge shows the travelling time, in minutes, between the corresponding pair of towns.

Use Dijkstra's algorithm on the diagram opposite to find the minimum travelling time from Hull (H) to Bridlington (B).

Show all temporary labels.

State the corresponding route.

(8 marks)

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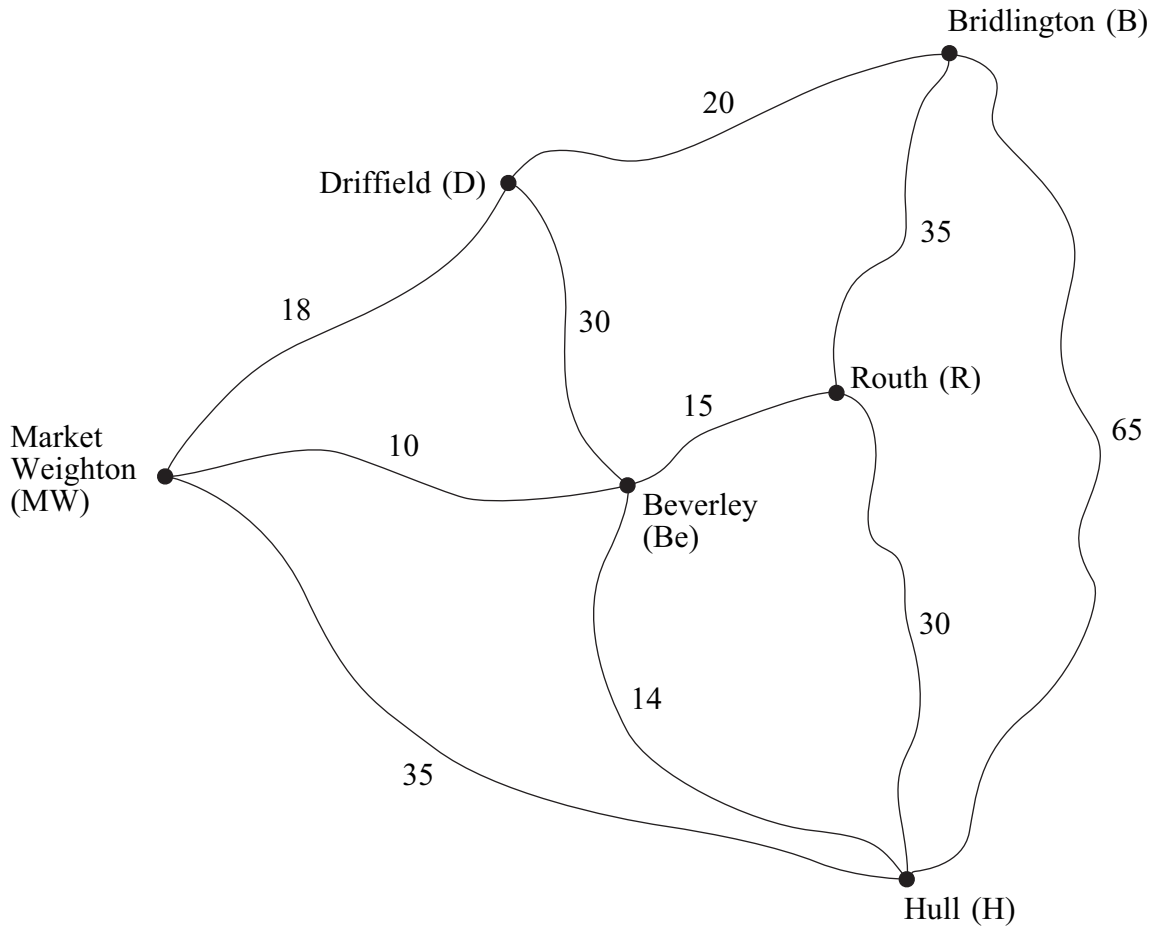
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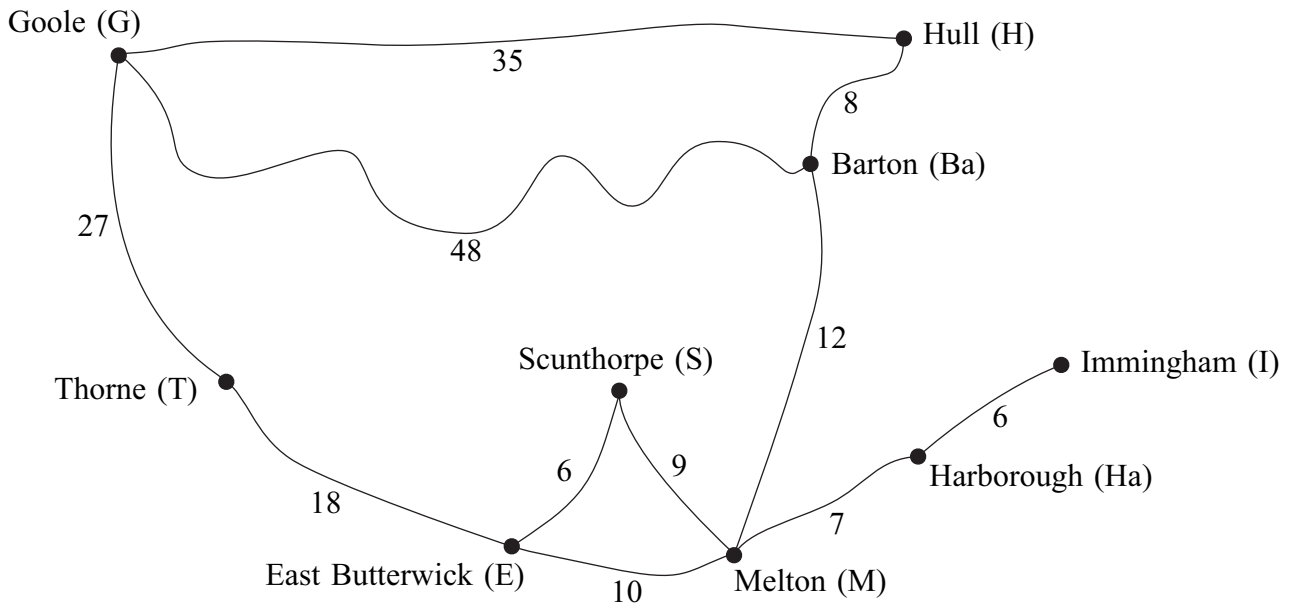
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4 The map below shows the locations of some places in South Humberside. The number on each edge shows the travelling time, in minutes, between the corresponding pair of towns.



Total of all these times = 186 minutes

The council uses a snow plough to clear all the roads of snow in winter in the minimum amount of time. The snow plough is based in Hull.

Use the Chinese postman algorithm to find the minimum travelling time of an optimal route for the snow plough.

Show all your working.

(5 marks)

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Section D

Answer **all** questions in the spaces provided.

Use **Towns in Sicily** on page 5 of the Data Sheet.

- 5** Angelo works for a recycling company that is based in Raffadali (R) and has five towns to visit to collect recyclable waste. Angelo wishes to arrange a tour to each of the other five towns in turn, starting from and finally returning to his base in Raffadali (R). The table shows the times it takes, in minutes, to drive between the towns.

	Aragona (A)	Canicatti (C)	Delia (D)	Favara (F)	Grotte (G)	Raffadali (R)
Aragona (A)	–	32	26	15	18	23
Canicatti (C)	32	–	20	31	28	38
Delia (D)	26	20	–	26	30	33
Favara (F)	15	31	26	–	32	24
Grotte (G)	18	28	30	32	–	41
Raffadali (R)	23	38	33	24	41	–

(A spare copy of this table, if needed, can be found on page 16)

The least possible total driving time of Angelo's tour is T minutes.

- (a) Starting from Raffadali (R), use the nearest neighbour algorithm to find an upper bound for T . (4 marks)
- (b) Starting from Grotte (G), use the nearest neighbour algorithm to find an upper bound for T . (4 marks)
- (c) Use your answer to part (b) to write down a tour starting from Raffadali (R). (1 mark)
- (d) By deleting Grotte, find a lower bound for T . (5 marks)
- (e) Use your answers to parts (a), (b) and (d) to write down the smallest interval within which you know T must lie. (2 marks)



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END OF QUESTIONS



1 5

Spare copy of table in question 5

	Aragona (A)	Canicatti (C)	Delia (D)	Favara (F)	Grotte (G)	Raffadali (R)
Aragona (A)	–	32	26	15	18	23
Canicatti (C)	32	–	20	31	28	38
Delia (D)	26	20	–	26	30	33
Favara (F)	15	31	26	–	32	24
Grotte (G)	18	28	30	32	–	41
Raffadali (R)	23	38	33	24	41	–

