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INTERNATIONAL A LEVEL MATHEMATICS • DECISION MATHEMATICS 1

Decision 1

Chapter 4: Route Inspection

Exam Questions by Topic

Pearson Edexcel International Advanced Level (WDM11/01) • Calculator allowed • Answer book pages included

Multi-step exam questions at the difficulty of the real WDM11 paper, with a full mark scheme

Chapters (tap a chapter to jump to it)		Qs	Marks	Page	My score
1	**Algorithms** Flow charts, bubble sort, quick sort, bin packing, binary search	10	80	separate file	
2	**Graphs and Networks** Vocabulary, types of graph, degrees, adjacency and distance matrices	10	80	separate file	
3	**Algorithms on Graphs** Kruskal, Prim (networks and matrices), Dijkstra	10	80	separate file	
4	**Route Inspection** Eulerian graphs, pairing odd vertices, start and finish points	10	80	2	
5	**The Travelling Salesman Problem** Classical and practical problems, upper and lower bounds	10	80	separate file	
6	**Critical Path Analysis** Activity networks, event times, floats, Gantt charts, scheduling	10	80	separate file	
7	**Linear Programming** Formulation, feasible regions, objective lines, integer solutions	10	80	separate file	

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CHAPTER 4 • KEY SKILLS

4 Route Inspection

Specification D1: Route inspection • 10 questions • 80 marks • about 96 minutes

1 Eulerian

All vertices even: a closed route can use every arc exactly once. Exactly two odd: semi-Eulerian, start at one odd vertex and finish at the other.

2 Odd vertices

List the odd vertices first: there are always an even number of them.

3 Pairings

Four odd vertices P, Q, R, S give three pairings: $PQ + RS$, $PR + QS$, $PS + QR$. Find every total.

4 Shortest paths

The repeated route between two odd vertices is the shortest path, which may use several arcs.

5 Route length

Total weight of the network plus the least pairing total.

6 Different start and finish

Leave two odd vertices unpaired as the start and finish; repeat the shortest path between the other two. Check every choice.

7 Writing a route

Any order that uses every arc once (and repeated arcs twice), starting and finishing where required.

8 Passing through

In a closed route a vertex of degree d appears $\frac{d}{2}$ times (count repeated arcs in the degree).

9 Changes

Adding or removing an arc changes the degrees: recount the odd vertices before pairing again.

Skills map every skill above is tested at least once; interleaved skills come from GCSE or other chapters

Skill	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Marks	6	6	6	6	6	10	10	10	10	10
1 Eulerian	•		•	•						
2 Odd vertices	•	•	•		•	•	•	•	•	•
3 Pairings		•			•	•	•	•	•	•
4 Shortest paths	•	•				•	•	•	•	•
5 Route length	•	•	•	•	•	•	•	•	•	•
6 Different start and finish			•		•	•				•
7 Writing a route	•			•						
8 Passing through				•						•
9 Changes							•	•		
Interleaved: Dijkstra's algorithm (Chapter 3)									•	
Interleaved: degrees and the handshaking lemma (Chapter 2)	•	•	•	•			•			
Interleaved: linear inequalities in an unknown (P1)								•		

Exam difficulty. Questions 1 to 5 check each skill on its own. Questions 6 to 10 are multi-step questions built like the last questions on a real WDM11 paper, where one part leads into the next.

Answer book. After each question is a copy of the page the real D1 answer book prints for it: the network reprinted (with Dijkstra boxes where needed) and answer lines.

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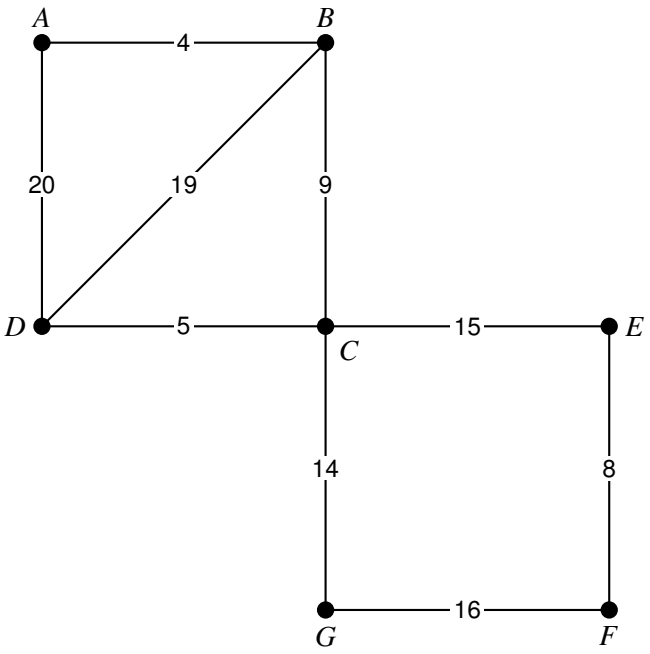


Figure 1

Figure 1 shows a network of paths in a park. The number on each arc is the length of the path, in hundreds of metres. A warden must walk along every path, starting and finishing at A.

(a) Explain why the warden must repeat some paths, and state which paths should be repeated.

(3)

(b) Find the length of the shortest route.

(1)

(c) Write down a possible shortest route.

(2)

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Question 1 continued D1 ANSWER BOOK

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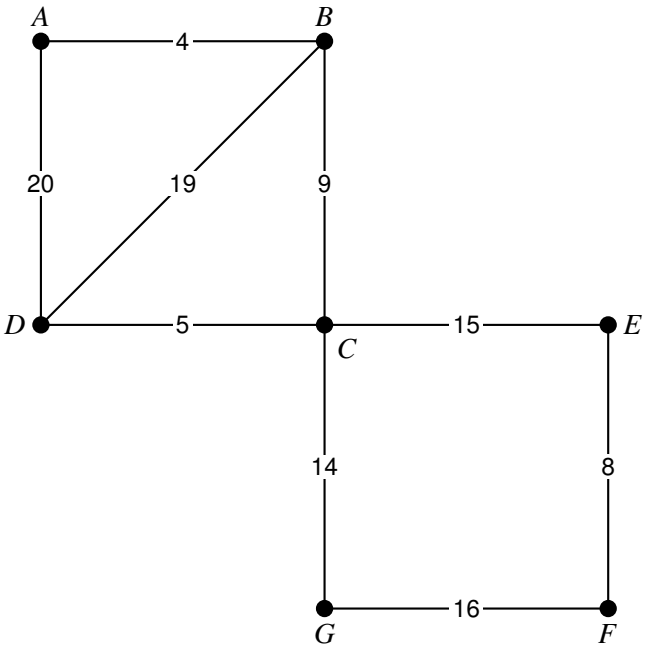


Diagram 1

Paths repeated: _____

Length of route: _____

Route: _____

(Total for Question 1 is 6 marks)

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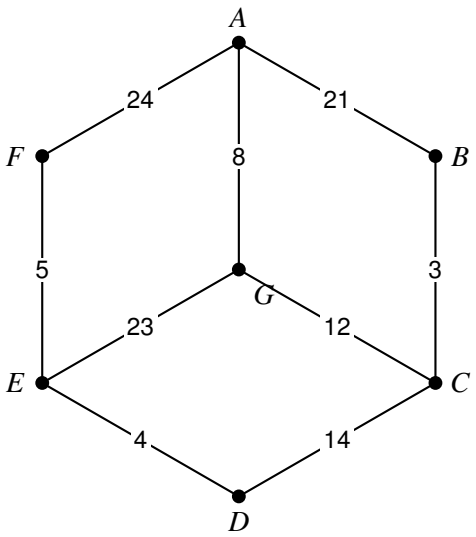


Figure 2

Figure 2 shows a network of roads. The number on each arc is the length of the road, in km. The total length of the roads is 114 km. A road gritter must travel along every road, starting and finishing at the depot B.

(a) Use the route inspection algorithm to find the roads that must be traversed twice. You must make your method clear, considering all possible pairings.

(5)

(b) Find the length of the shortest route.

(1)

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Question 2 continued D1 ANSWER BOOK

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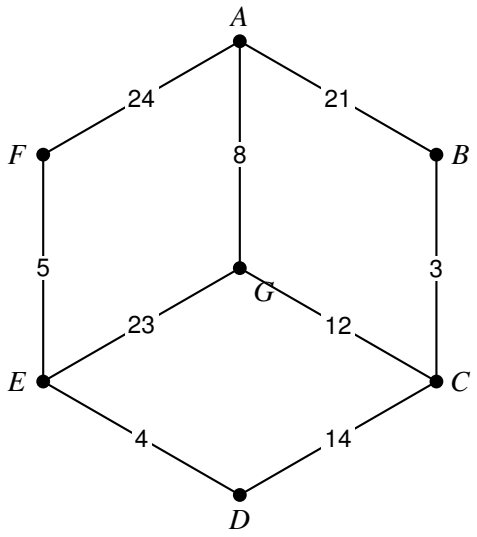


Diagram 2

Roads traversed twice: _____

Length of route: _____

(Total for Question 2 is 6 marks)

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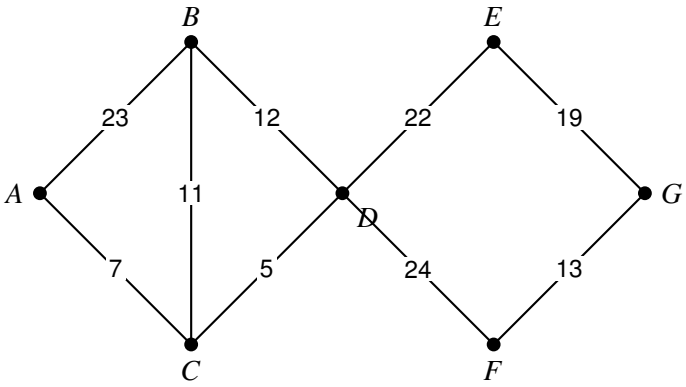


Figure 3

The corridors of a museum are modelled by the network in Figure 3, with weights giving corridor lengths in metres.

(a) A visitor wishes to use each corridor once only. Show that this can be done, and identify the two rooms where the visit must begin and end.

(2)

(b) Find the length of this walk.

(1)

(c) A guard must walk along every corridor, starting and finishing at A. Find the length of the shortest route, stating which corridor or corridors are repeated.

(3)

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Question 3 continued D1 ANSWER BOOK

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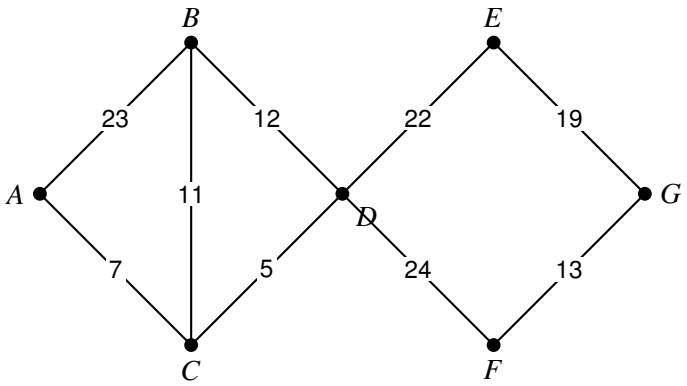


Diagram 3

Start and finish: _____

Corridors repeated: _____

Length of route: _____

(Total for Question 3 is 6 marks)

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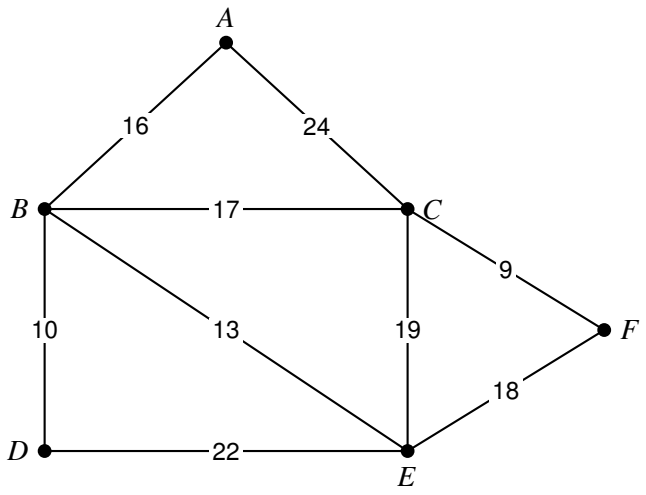


Figure 4

A postal worker's streets form the network in Figure 4; arc weights are street lengths in hundreds of metres.

(a) Explain why the postal worker can walk along every street exactly once and return to the start.

(1)

(b) Write down a suitable route starting and finishing at A, and state its length.

(3)

(c) State the number of times the route passes through B, giving a reason.

(2)

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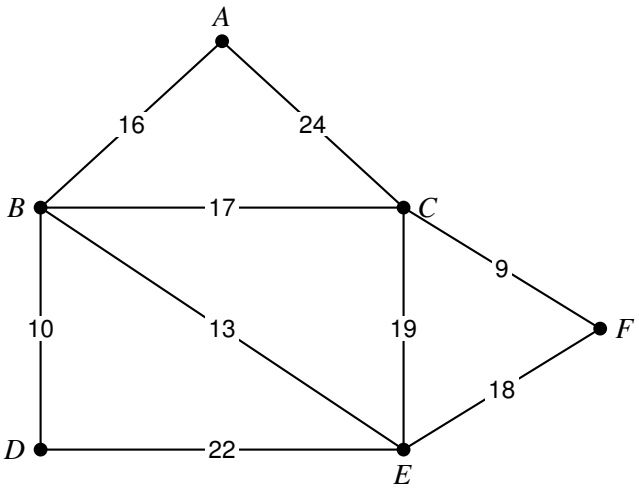


Diagram 4

Route: _____

Length of route: _____

(Total for Question 4 is 6 marks)

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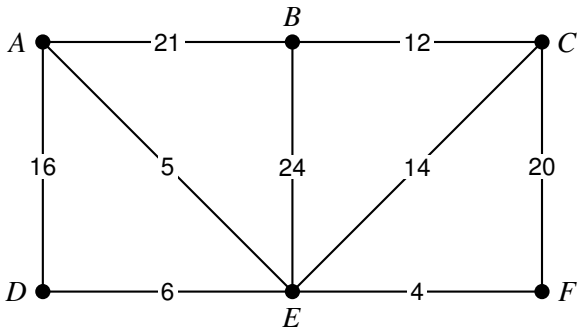


Figure 5

Cycle tracks with lengths in km form the network in Figure 5 (total 122 km). Every track is to be checked by one rider.

(a) Find the length of the shortest route that covers every track and starts and finishes at D, considering all pairings of the odd vertices.

(3)

(b) The route must instead start at E and may finish at any vertex. Find where it should finish and its length, explaining your choice.

(3)

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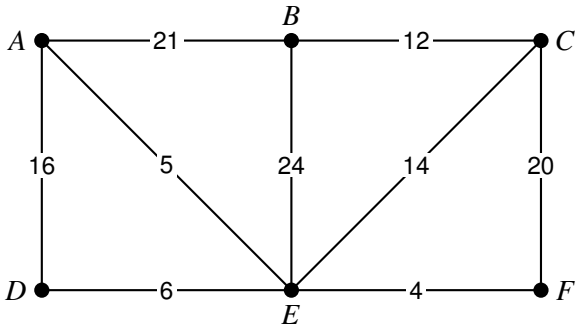


Diagram 5

Length of closed route: _____

Finish point and length of route from E: _____

(Total for Question 5 is 6 marks)

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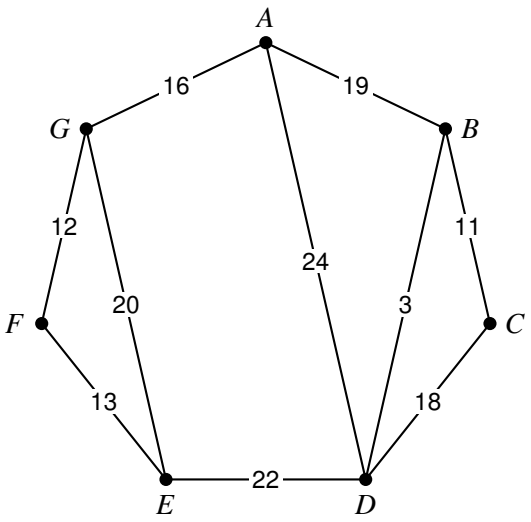


Figure 6

An engineer must inspect each road in Figure 6. Weights are lengths in km, and together the roads total 158 km.

(a) Use the route inspection algorithm to find the shortest route that starts and finishes at the same vertex. You must state which roads are repeated, show your consideration of all pairings, and give the length of the route.

(5)

(b) The route may instead start and finish at different vertices. Find the starting and finishing vertices that give the shortest route, and its length, justifying your choice.

(3)

(c) The inspector must start at G. State where the route should now finish, and its length.

(2)

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Question 6 continued D1 ANSWER BOOK

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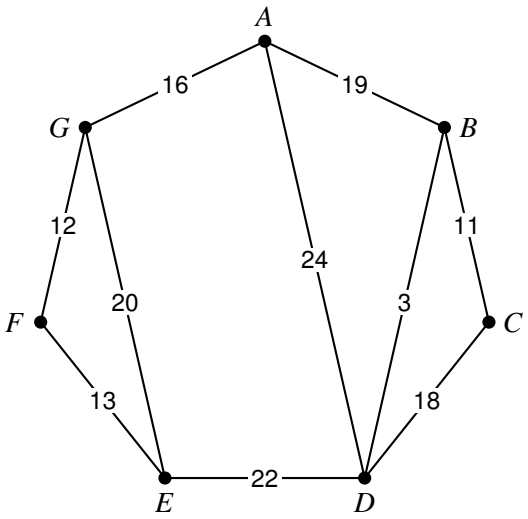


Diagram 6

Roads repeated: _____

Length of route: _____

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Question 6 continued

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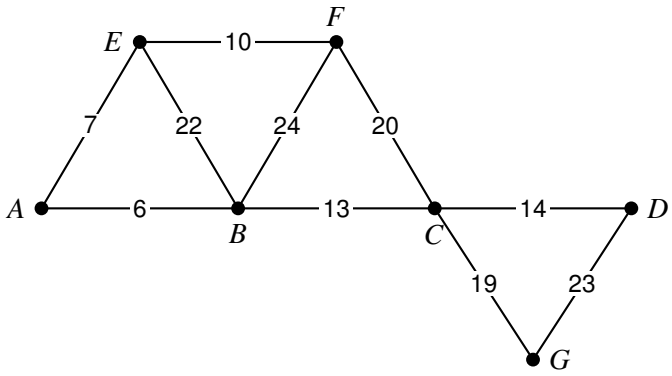


Figure 7

Figure 7 shows the network of footpaths in a nature reserve. The number on each arc is the length of the path, in hundreds of metres. The total length of the paths is 158.

(a) A ranger must walk every path, starting and finishing at A. Find the length of the shortest route, stating which paths are repeated.

(3)

A new path BG, of length 17, is built. It must also be walked.

(b) Explain the effect of the new path on the odd vertices, and use the route inspection algorithm to find the new shortest route length, showing all pairings.

(6)

(c) Comment on how the new route length compares with your answer to part (a).

(1)

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Question 7 continued D1 ANSWER BOOK

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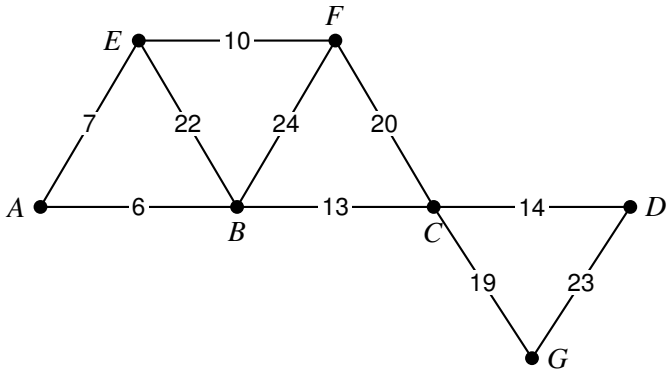


Diagram 7

Length of route in part (a): _____

Length of route in part (b): _____

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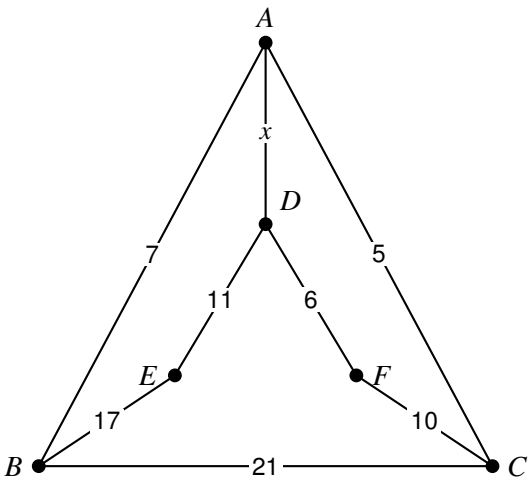


Figure 8

Figure 8 shows a network of pipes. The number on each arc is the length of the pipe, in metres. The length of AD is x metres, where $x > 0$. Every pipe must be inspected by a route that starts and finishes at A.

(a) Find, in terms of x, the total length of the pipes, and the total of each of the three pairings of the odd vertices.

(4)

(b) Find the range of values of x for which AD should be repeated, and write down the length of the route in each case.

(3)

(c) The shortest route has length 116 m. Find x, showing that the other case is impossible.

(3)

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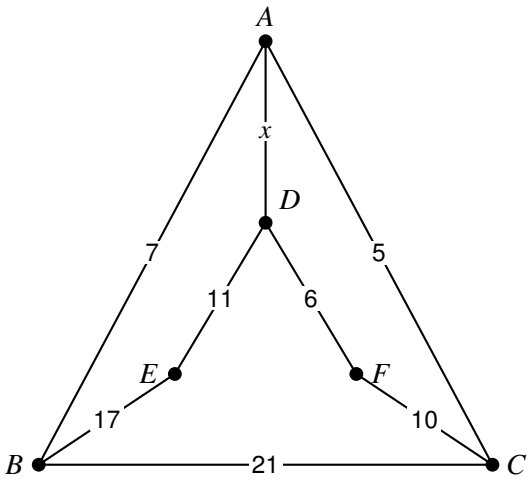


Diagram 8

Length of route in terms of x: _____

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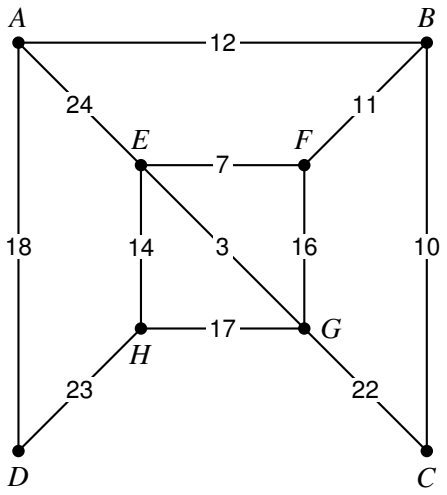


Figure 9

In Figure 9, each arc is a village road marked with its length in hundreds of metres; together the roads total 177.

(a) Use Dijkstra's algorithm to find the shortest distances from A to each of the other vertices.

(5)

A road sweeper must travel along every road, starting and finishing at A.

(b) Using your answer to part (a) where possible, find the roads that must be traversed twice, showing all pairings.

(4)

(c) Find the length of the shortest route.

(1)

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Question 9 continued D1 ANSWER BOOK

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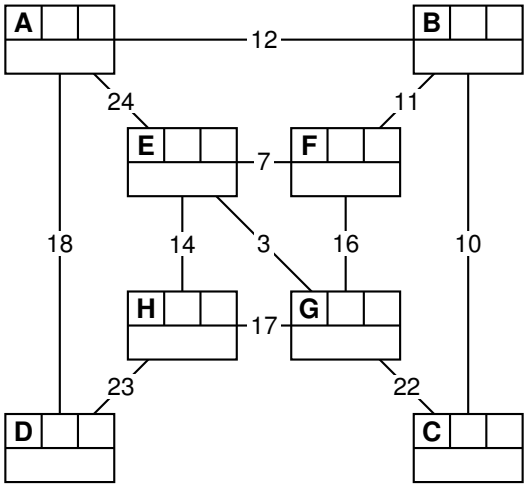


Diagram 9

Key:

Vertex	Order of labelling	Final value
Working values		

Roads traversed twice: _____

Length of route: _____

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Question 9 continued

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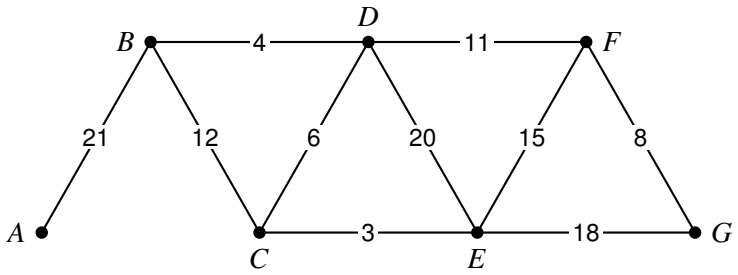


Figure 10

Figure 10 shows a network of streets to be cleaned. The number on each arc is the length of the street, in hundreds of metres. The total length of the streets is 118.

(a) Use the route inspection algorithm to find the length of the shortest route that starts and finishes at A. You must make your method clear.

(5)

(b) The cleaning vehicle must start at A but may finish at any vertex. Determine where it should finish, the streets it repeats and the length of the route, justifying your answer.

(4)

(c) State the number of times the route in part (b) passes through D.

(1)

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Question 10 continued D1 ANSWER BOOK

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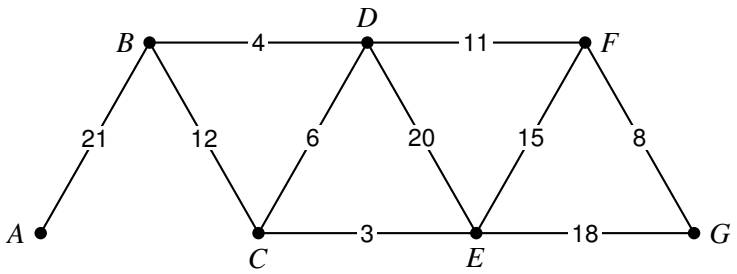


Diagram 10

Length of closed route: _____

Finishing point: _____

Length of route: _____

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TOTAL FOR CHAPTER 4 IS 80 MARKS

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