Pearson Edexcel International Advanced Level

Time 1 hour 30 minutes

Paper reference **WDM11/01**

Mathematics

International Advanced Subsidiary/Advanced Level
Decision Mathematics D1

You must have:
Decision Mathematics Answer Book (enclosed), calculator

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- Write your answers for this paper in the Decision Mathematics answer book provided.
- **Fill in the boxes** at the top of the answer book with your name, centre number and candidate number.
- Do not return the question paper with the answer book.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

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Write your answers in the D1 answer book for this paper.

1. (a) Explain what is meant by the term 'path'.

(2)

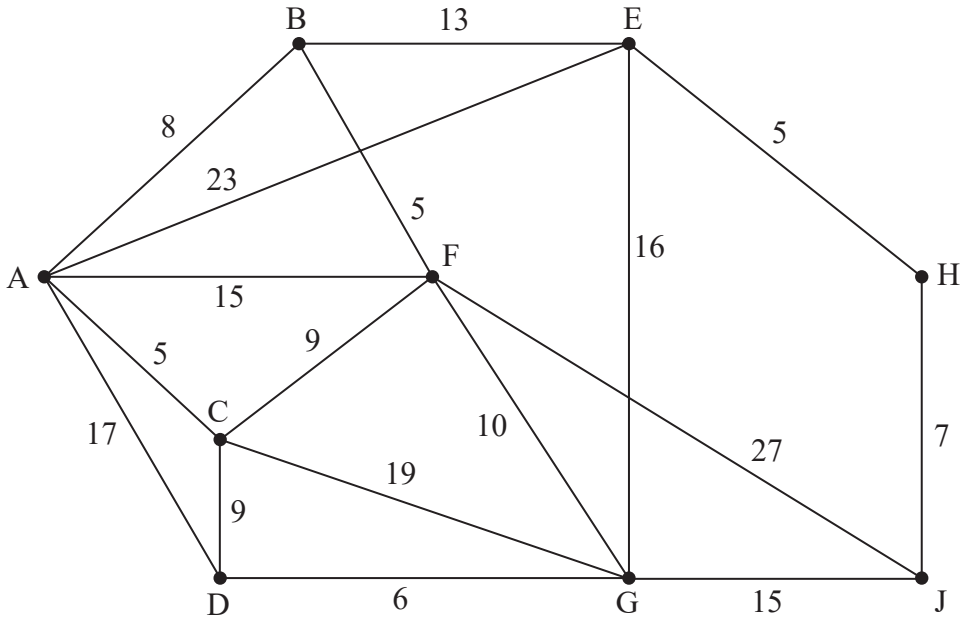

Figure 1

Figure 1 represents a network of roads. The number on each arc represents the length, in km, of the corresponding road. Piatrice wishes to travel from A to J.

(b) Use Dijkstra's algorithm to find the shortest path Piatrice could take from A to J. State your path and its length.

(6)

Piatrice needs to return from J to A via G.

(c) Find the shortest path Piatrice could take from J to A via G and state its length.

(2)

(Total 10 marks)

2. Chris has been asked to design a badge in the shape of a triangle XYZ subject to the following constraints.

- Angle Y should be at least three times the size of angle X
- Angle Z should be at least 50° larger than angle X
- Angle Y must be at most 120°

Chris has been asked to maximise the sum of the angles X and Y.

Let x be the size of angle X in degrees.

Let y be the size of angle Y in degrees.

Let z be the size of angle Z in degrees.

Formulate this information as a linear programming problem in x and y **only**. State the objective and list the constraints as simplified inequalities with integer coefficients.

You are **not** required to solve this problem.

(6)

(Total 6 marks)

3. The table below represents a complete network that shows the least costs of travelling between eight cities, A, B, C, D, E, F, G and H.

	A	B	C	D	E	F	G	H
A	–	36	38	40	23	39	38	35
B	36	–	35	36	35	34	41	38
C	38	35	–	39	25	32	40	40
D	40	36	39	–	37	37	26	33
E	23	35	25	37	–	42	24	43
F	39	34	32	37	42	–	45	38
G	38	41	40	26	24	45	–	40
H	35	38	40	33	43	38	40	–

Srinjoy must visit each city at least once. He will start and finish at A and wishes to minimise his total cost.

(a) Use Prim's algorithm, starting at A, to find a minimum spanning tree for this network. You must list the arcs that form the tree in the order in which you select them.

(3)

(b) State the weight of the minimum spanning tree.

(1)

(c) Use your answer to (b) to help you calculate an initial upper bound for the total cost of Srinjoy's route.

(1)

(d) Show that there are two nearest neighbour routes that start from A. You must make the routes and their corresponding costs clear.

(4)

(e) State the best upper bound that can be obtained by using your answers to (c) and (d).

(1)

(f) Starting by deleting A and all of its arcs, find a lower bound for the total cost of Srinjoy's route. You must make your method and working clear.

(3)

(g) Use your results to write down the smallest interval that must contain the optimal cost of Srinjoy's route.

(2)

(Total 15 marks)

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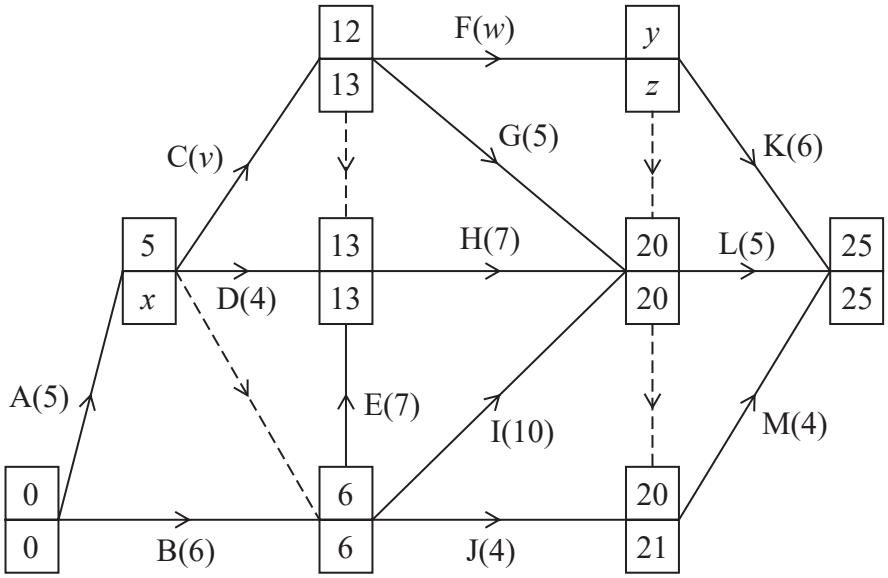


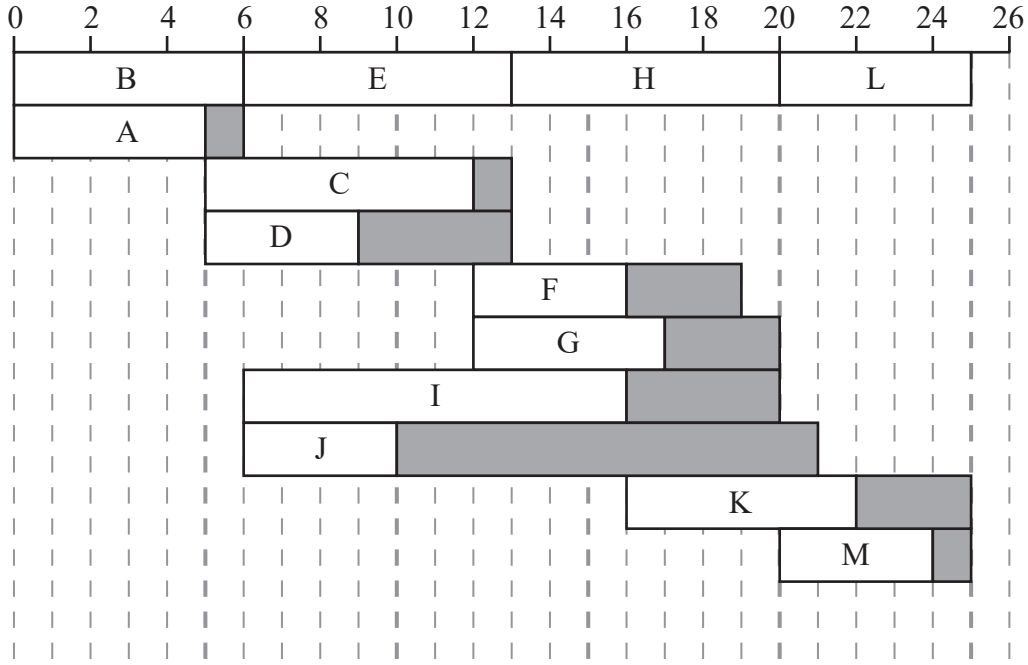
Figure 2

The network in Figure 2 shows the activities that need to be carried out by a company to complete a project. Each activity is represented by an arc, and the duration, in days, is shown in brackets. Each activity requires one worker. The early event times and the late event times are shown at each vertex.

(a) Complete the precedence table in the answer book.

(2)

A cascade chart for this project is shown on Grid 1.



Grid 1

(b) Use Figure 2 and Grid 1 to find the values of v, w, x, y and z.

(3)

The project is to be completed in the minimum time using as few workers as possible.

(c) Calculate a lower bound for the minimum number of workers required. You must show your working.

(1)

(d) On Grid 2 in your answer book, construct a scheduling diagram for this project.

(3)

Before the project begins it is found that activity F will require an additional 5 hours to complete. The durations of all other activities are unchanged. The project is still to be completed in the shortest possible time using as few workers as possible.

(e) State the new minimum project completion time and state the new critical path.

(2)

(Total 11 marks)

5.

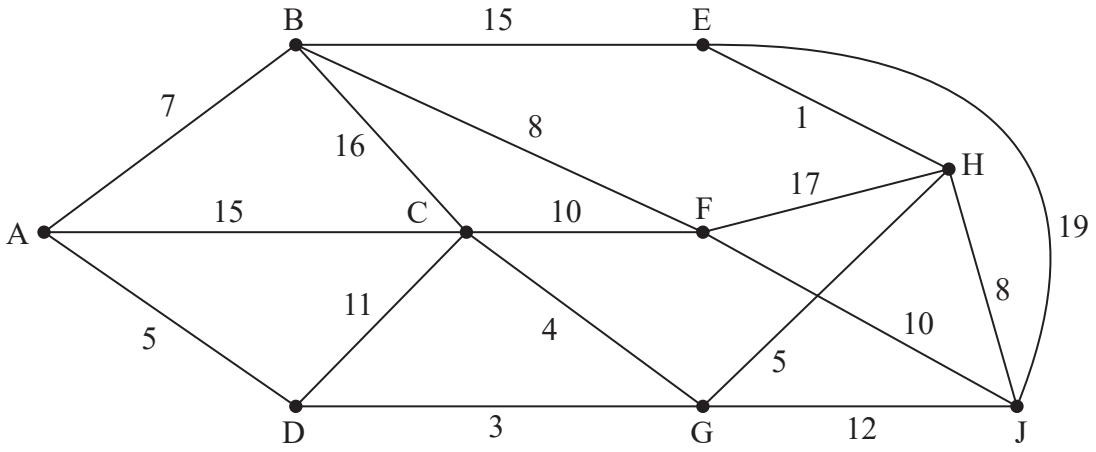


Figure 3

[*The total weight of the network is* 166]

Figure 3 models a network of cycle lanes that must be inspected. The number on each arc represents the length, in km, of the corresponding cycle lane. Lance needs to cycle along each lane at least once and wishes to minimise the length of his inspection route.

He must start and finish at A.

(a) Use an appropriate algorithm to find the length of the route. State the cycle lanes that Lance will need to traverse twice. You should make your method and working clear.

(6)

(b) State the number of times that vertex C appears in Lance's route.

(1)

It is now decided that the inspection route may finish at any vertex. Lance will still start at A and must cycle along each lane at least once.

(c) Determine the finishing point so that the length of the route is minimised. You must give reasons for your answer and state the length of this new minimum route.

(3)

(Total 10 marks)

6. A linear programming problem in x and y is described as follows.

Maximise $P = kx + y$, where k is a constant

subject to: $3y \geqslant x$

$x + 2y \leqslant 130$

$4x + y \geqslant 100$

$4x + 3y \leqslant 300$

(a) Add lines and shading to Diagram 1 in the answer book to represent these constraints. Hence determine the feasible region and label it R.

(4)

(b) For the case when $k = 0.8$

(i) use the objective line method to find the optimal vertex, V, of the feasible region. You must draw and label your objective line and label vertex V clearly.

(2)

(ii) calculate the coordinates of V and hence calculate the corresponding value of P at V.

(3)

Given that for a different value of k, V is not the optimal vertex of R,

(c) determine the range of possible values for k. You must make your method and working clear.

(4)

(Total 13 marks)

7. The numbers listed below are to be packed into bins of size n, where n is a positive integer.

14 20 23 17 15 22 19 25 13 28 32

A lower bound for the number of bins required is 4

(a) Determine the range of possible values of n. You must make your method clear.

(3)

(b) Carry out a quick sort to produce a list of the numbers in descending order. You should show the result of each pass and identify your pivots clearly.

(4)

When the first-fit bin packing algorithm is applied to the **original** list of numbers, the following allocation is achieved.

Bin 1: 14 20 23 15

Bin 2: 17 22 19 13

Bin 3: 25 28

Bin 4: 32

When the first-fit decreasing bin packing algorithm is applied to the sorted list of numbers, the following allocation is achieved.

Bin 1: 32 28

Bin 2: 25 23 22

Bin 3: 20 19 17 15

Bin 4: 14 13

(c) Determine the value of n. You must explain your reasoning fully.

(3)

(Total 10 marks)

TOTAL FOR PAPER: 75 MARKS

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Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Time 1 hour 30 minutes

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Decision Mathematics D1

Answer Book

Do not return the question paper with the answer book.

Total Marks

Turn over ▶

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1.

(a) _____

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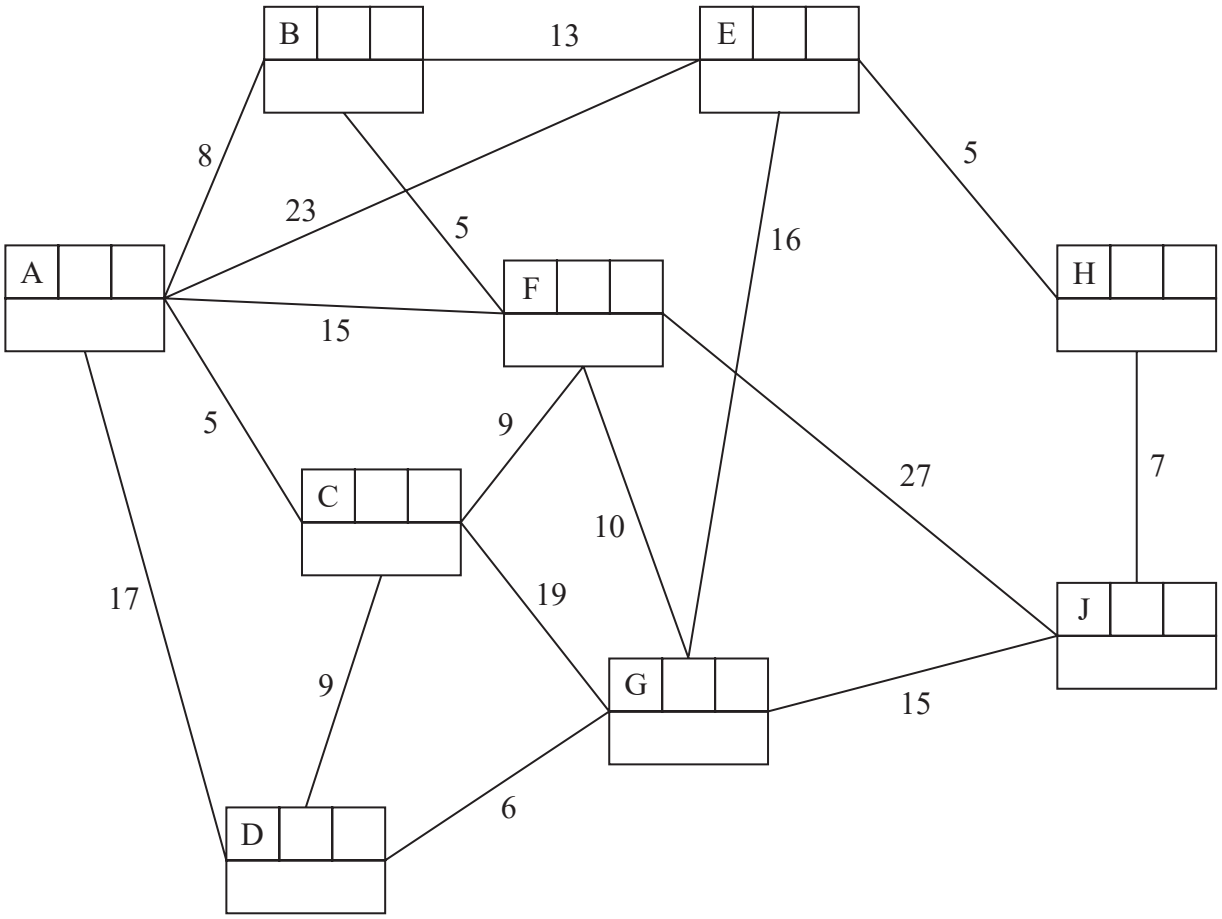
Key:

Vertex	Order of labelling	Final value
Working values		



Shortest path from A to J: _____

Length of shortest path from A to J: _____

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Question 1 continued

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Q1

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Question 2 continued

Q2

(Total 6 marks)

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3.

	A	B	C	D	E	F	G	H
A	–	36	38	40	23	39	38	35
B	36	–	35	36	35	34	41	38
C	38	35	–	39	25	32	40	40
D	40	36	39	–	37	37	26	33
E	23	35	25	37	–	42	24	43
F	39	34	32	37	42	–	45	38
G	38	41	40	26	24	45	–	40
H	35	38	40	33	43	38	40	–

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Question 3 continued

	A	B	C	D	E	F	G	H
A	–	36	38	40	23	39	38	35
B	36	–	35	36	35	34	41	38
C	38	35	–	39	25	32	40	40
D	40	36	39	–	37	37	26	33
E	23	35	25	37	–	42	24	43
F	39	34	32	37	42	–	45	38
G	38	41	40	26	24	45	–	40
H	35	38	40	33	43	38	40	–

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Question 3 continued

	A	B	C	D	E	F	G	H
A	–	36	38	40	23	39	38	35
B	36	–	35	36	35	34	41	38
C	38	35	–	39	25	32	40	40
D	40	36	39	–	37	37	26	33
E	23	35	25	37	–	42	24	43
F	39	34	32	37	42	–	45	38
G	38	41	40	26	24	45	–	40
H	35	38	40	33	43	38	40	–

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Question 3 continued

	A	B	C	D	E	F	G	H
A	–	36	38	40	23	39	38	35
B	36	–	35	36	35	34	41	38
C	38	35	–	39	25	32	40	40
D	40	36	39	–	37	37	26	33
E	23	35	25	37	–	42	24	43
F	39	34	32	37	42	–	45	38
G	38	41	40	26	24	45	–	40
H	35	38	40	33	43	38	40	–

Q3

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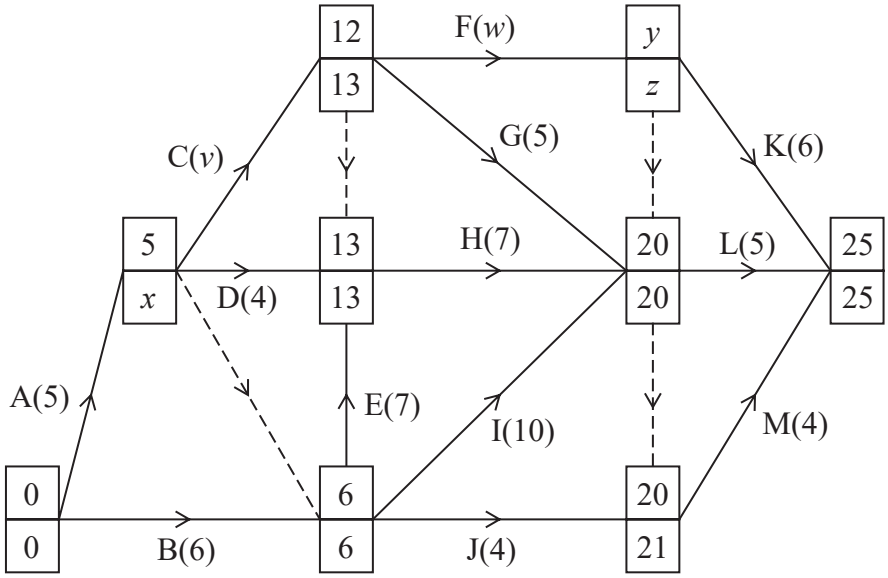

Figure 2

(a)

Activity	Immediately preceding activities
A	
B	
C	
D	
E	

Activity	Immediately preceding activities
F	
G	
H	
I	
J	

Activity	Immediately preceding activities
K	
L	
M	

$v =$ _____ $w =$ _____ $x =$ _____ $y =$ _____ $z =$ _____

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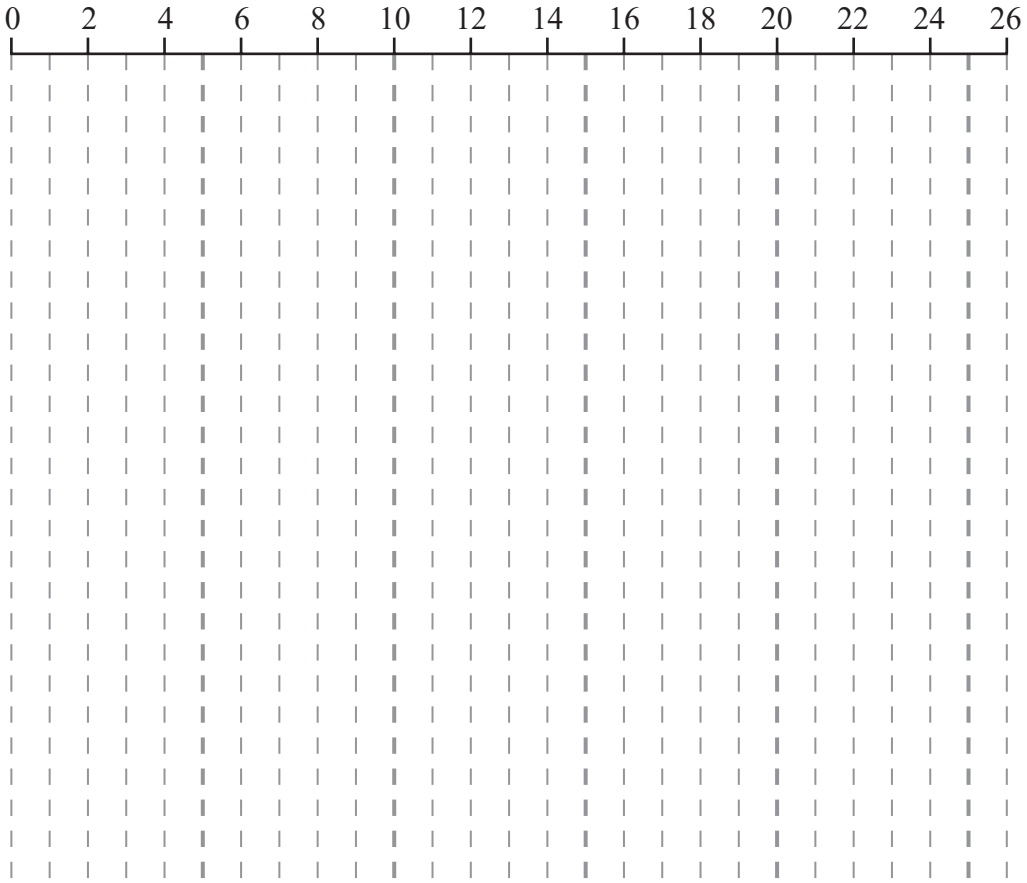
Question 4 continued



Grid 2

Q4

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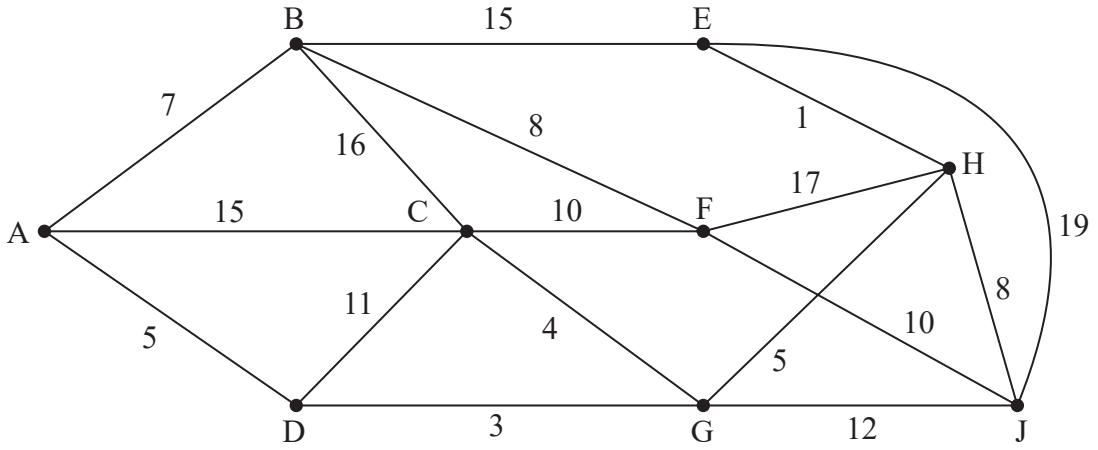

Figure 3

[*The total weight of the network is* 166]

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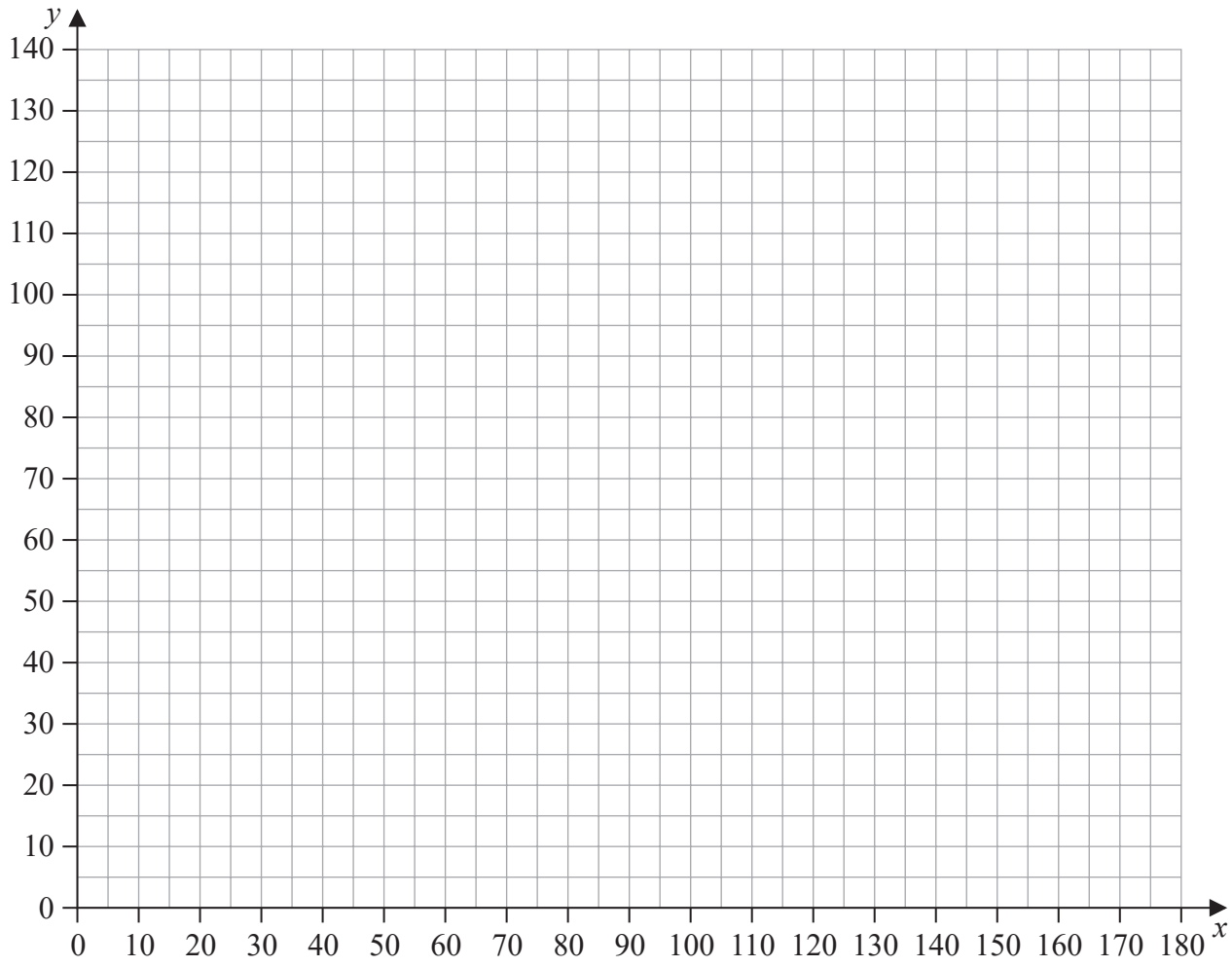

Diagram 1

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Q6

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Q7

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