MATHEMATICS DEPARTMENT

YEAR 12 TO YEAR 13 TRANSITION BOOKLET

Preparation for Y13 Further Mathematics

Bridging the Gap from Year 12 to Year 13

This booklet contains a structured collection of supplementary practice questions focusing on all D1 content. Mastering these topics is essential for establishing fluency and maintaining a confident start to Year 13.

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Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Algorithms

You must have:
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

Instructions

- Use black ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- Fill in the boxes at the top of this page with your name, centre number and candidate number.
- Answer all the 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

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 95.
- The marks for each question are shown in brackets – use this as a guide as to how much time to spend on each question.
- Calculators must not be used for questions marked with a * sign.

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.

1.

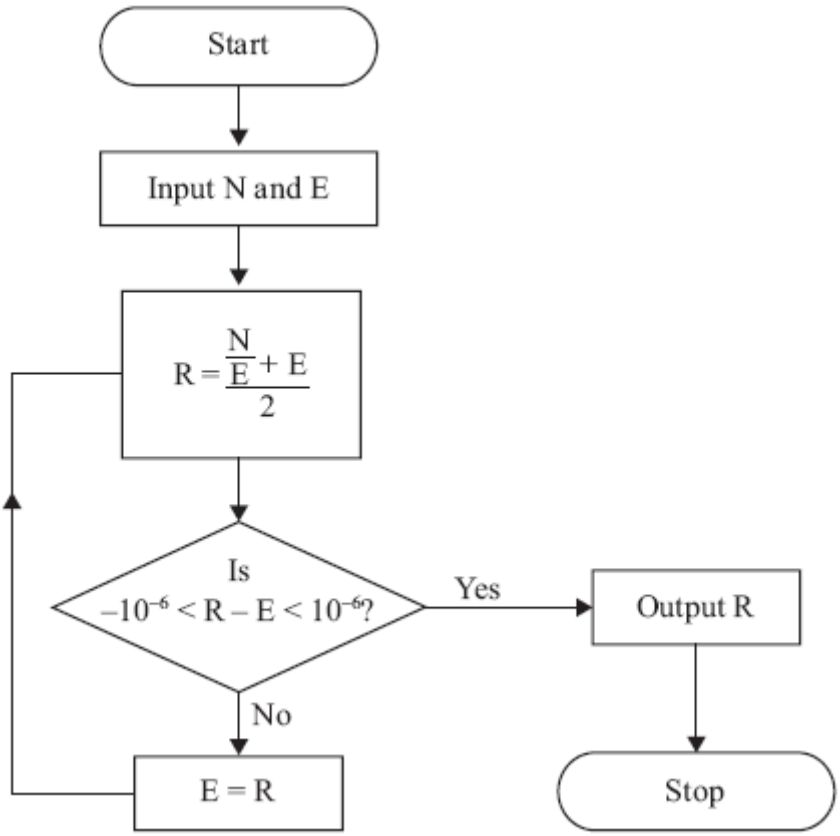

Figure 1

Hero's algorithm for finding a square root is described by the flow chart shown in Figure 1.

Given that N = 72 and E = 8,

(*a*) use the flow chart to complete the table in the answer book, working to at least seven decimal places when necessary. Give the final output correct to seven decimal places.

(4)

The flow chart is used with N = 72 and E = – 8,

(*b*) describe how this would affect the output.

(1)

(*c*) State the value of E which cannot be used when using this flow chart.

(1)

(Total 6 marks)

2.

31 10 38 45 19 47 35 28 12

(*a*) Use the first-fit bin packing algorithm to determine how the numbers listed above can be packed into bins of size 60.

(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)

(*c*) Use the first-fit decreasing bin packing algorithm to determine how the numbers listed can be packed into bins of size 60.

(2)

(*d*) Determine whether the number of bins used in (*c*) is optimal. Give a reason for your answer.

(2)

(Total 11 marks)

3.

0.6 1.5 1.6 0.2 0.4 0.5 0.7 0.1 0.9 0.3

(*a*) Use the first-fit bin packing algorithm to determine how the numbers listed above can be packed into bins of size 2.

(3)

(*b*) The list of numbers is to be sorted into **descending order**. Use a quick sort to obtain the sorted list. You must make your pivots clear.

(4)

(*c*) Apply the first-fit decreasing bin packing algorithm to your ordered list to pack the numbers into bins of size 2.

(3)

(*d*) Determine whether your answer to part (*c*) uses the minimum number of bins. You must justify your answer.

(1)

(Total 11 marks)

4.

23 29 11 34 10 14 35 17

The numbers represent the sizes, in megabytes (MB), of eight files.

The files are to be stored on 50 MB discs.

(*a*) Calculate a lower bound for the number of discs needed to store all eight files.

(2)

(*b*) Use the first-fit bin packing algorithm to fit the files onto the discs.

(3)

(*c*) Perform a bubble sort on the numbers in the list to sort them into descending order. You need only write down the final result of each pass.

(4)

(*d*) Use the first-fit decreasing bin packing algorithm to fit the files onto the discs.

(3)

(Total 12 marks)

5.

42 21 15 16 35 10 31 11 27 39

(*a*) Use the first-fit bin packing algorithm to determine how the numbers listed above can be packed into bins of size 65.

(3)

(*b*) The list of numbers is to be sorted into descending order. Use a quick sort to obtain the sorted list. You should show the result of each pass and identify your pivots clearly.

(4)

(*c*) Use the first-fit decreasing bin packing algorithm on your ordered list to pack the numbers into bins of size 65.

(3)

The nine distinct numbers below are to be sorted into descending order

23 14 17 ***x*** 21 18 8 20 11

A bubble sort, starting at the left-hand end of the list, is to be used to obtain the sorted list. After the first complete pass, the list is

23 17 ***x*** 21 18 14 20 11 8

After the second complete pass, the list is

23 17 21 18 ***x*** 20 14 11 8

(*d*) Using this information, write down the smallest interval that must contain x. Give your answer as an inequality.

(3)

(Total 13 marks)

6.

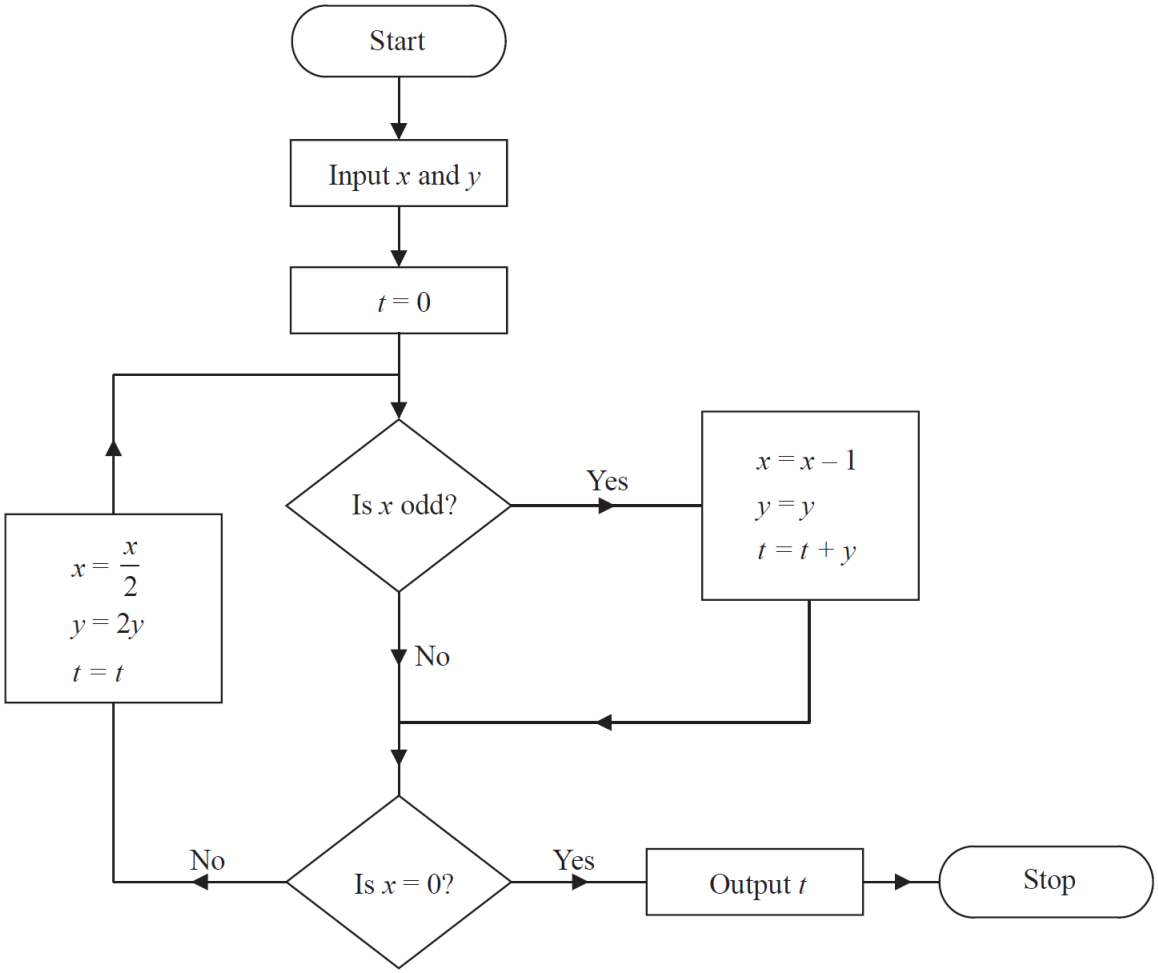

Figure 4

An algorithm is described by the flow chart shown in Figure 4.

Given that $x = 27$ and $y = 5$,

(*a*) complete the table in the answer book to show the results obtained at each step when the algorithm is applied. Give the final output.

(4)

The numbers 122 and $\frac{1}{2}$ are to be used as inputs for the algorithm described by the flow chart.

(*b*) (i) State, giving a reason, which number should be input as x.

(ii) State the output.

(3)

(Total 7 marks)

7.

59 45 18 55 47 11 63 17 15 42

(*a*) The list of numbers above is to be sorted into descending order. Perform a quick sort to obtain the sorted list. You should show the result of each pass and identify your pivots clearly.

(4)

The numbers in the list represent the lengths, in cm, of some pieces of copper wire. The copper wire is sold in one metre lengths.

(*b*) Use the first-fit decreasing bin packing algorithm to determine how these pieces could be cut from one metre lengths. (You should ignore wastage due to cutting.)

(3)

(*c*) Determine whether your solution to (*b*) is optimal. Give a reason for your answer.

(2)

(Total 9 marks)

8.

5 1 8 13 16 5 8 2 15 12 10

(*a*) Use the first-fit bin packing algorithm to determine how the numbers listed above can be packed into bins of size 20.

(3)

(*b*) The list of numbers is to be sorted into **descending** order. Use a bubble sort to obtain the sorted list, giving the state of the list after each **complete** pass.

(5)

(*c*) Apply the first-fit decreasing bin packing algorithm to your ordered list to pack the numbers into bins of size 20.

(3)

(*d*) Determine whether your answer to (*c*) uses the minimum number of bins. You must justify your answer.

(2)

(Total 13 marks)

9.

24 14 8 x 19 25 6 17 9

The numbers in the list represent the exact weights, in kilograms, of 9 suitcases. One suitcase is weighed inaccurately and the only information known about the unknown weight, x kg, of this suitcase is that $19 < x \leq 23$. The suitcases are to be transported in containers that can hold a maximum of 50 kilograms.

(*a*) Use the first-fit bin packing algorithm, on the list provided, to allocate the suitcases to containers.

(3)

(*b*) Using the list provided, carry out a quick sort to produce a list of the weights in **descending** order. Show the result of each pass and identify your pivots clearly.

(4)

(*c*) Apply the first-fit decreasing bin packing algorithm to the ordered list to determine the 2 possible allocations of suitcases to containers.

(4)

After the first-fit decreasing bin packing algorithm has been applied to the ordered list, one of the containers is full.

(*d*) Calculate the possible integer values of x. You must show your working.

(2)

(Total 13 marks)

TOTAL FOR PAPER: 95 MARKS

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | | | | | |

Candidate Number | | | | |

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Algorithms

Answer Book
Do not return the question paper with the answer book.

Total Marks

1. *You may not need to use all the rows in the table*

N	E	R	Is $-10^{-6} < R - E < 10^{-6}$?

Final output…….

Question 1 continued

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Question 4 continued

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(Total 12 marks)

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42 21 15 16 35 10 31 11 27 39

Question 5 continued

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(Total 13 marks)

6. (a) *You may not need to use all the rows in the table.*

It may not be necessary to complete all the boxes in each row.

x	y	T	Is x odd?	Is $x = 0$?
27	5	0	Yes	

Question 6 continued

Final output …….

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24 14 8 x 19 25 6 17 9

Question 9 continued

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(Total 13 marks)

TOTAL FOR PAPER: 95 MARKS

Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Critical path analysis

You must have:
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

Instructions

- Use black ink or ball-point pen.
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Information

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- There are 11 questions in this question paper. The total mark for this paper is 130.
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Advice

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- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

1. Draw the activity network described in the precedence table below, using activity on arc and exactly three dummies.

Activity	Immediately preceding activities
A	–
B	–
C	A
D	A
E	B
F	B
G	A, E, F
H	F
I	C
J	D, G
K	D, G

(Total 5 marks)

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2. (*a*) Draw the activity network described in the precedence table below, using activity on arc and exactly two dummies.

(5)

Activity	Immediately preceding activities
A	–
B	–
C	–
D	*A*, *B*
E	*C*
F	*A*, *B*
G	*A*, *B*
H	*E*, *F*
I	*D*
J	*D*, *G*
K	*H*

(*b*) Explain why each of the two dummies is necessary.

(2)

(Total 7 marks)

3.

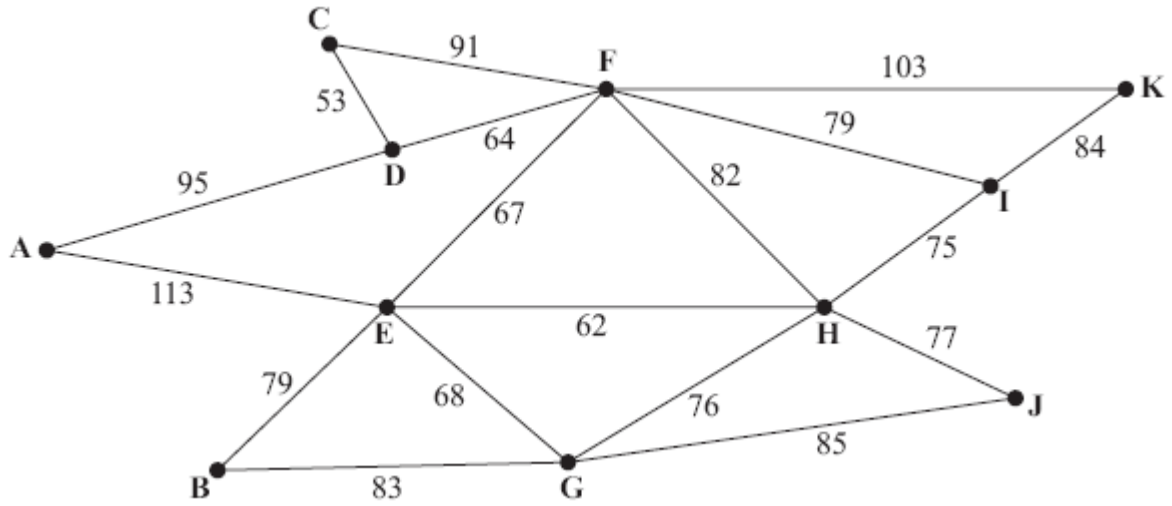

Figure 1

[*The total weight of the network is 1436 m*.]

(*a*) Explain the term **valency**.

(2)

Figure 1 models a system of underground pipes. The number on each arc represents the length, in metres, of that pipe.

Pressure readings indicate that there is a leak in the system and an electronic device is to be used to inspect the system to locate the leak. The device will start and finish at **A** and travel along each pipe at least once. The length of this inspection route needs to be minimised.

(*b*) Use the route inspection algorithm to find the pipes that will need to be traversed twice. You should make your method and working clear.

(5)

(*c*) Find the length of the inspection route.

(1)

Pipe **HI** is now found to be blocked; it is sealed and will not be replaced. An inspection route is now required that excludes pipe **HI**. The length of the inspection route must be minimised.

(*d*) Find the length of the minimum inspection route excluding **HI**. Justify your answer.

(2)

(*e*) Given that the device may now start at any vertex and finish at any vertex, find a minimum inspection route, excluding **HI**.

(2)

(Total 12 marks)

4.

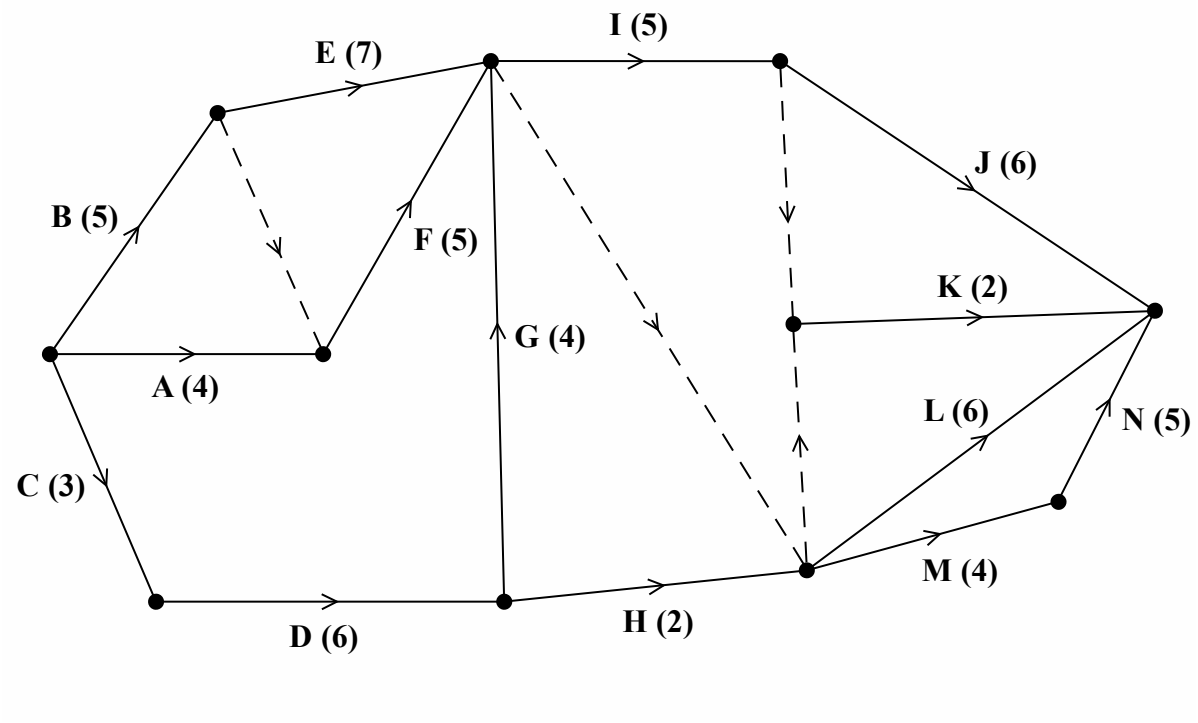

Figure 2

A project is modelled by the activity network shown in Figure 2. The activities are represented by the arcs. The number in brackets on each arc gives the time, in days, to complete the corresponding activity. Each activity requires exactly one worker. The project is to be completed in the shortest possible time.

(*a*) Complete Diagram 1 in the answer book to show the early event times and the late event times.

(4)

(*b*) Draw a Gantt chart for the project on the grid provided in the answer book.

(4)

(*c*) State the activities that must be happening at time 18.5

(1)

An additional activity, P, is now included in the activity network shown in Figure 6. Activity P is immediately preceded only by activity D. No activity is dependent on the completion of activity P.

Each activity still requires exactly one worker and the revised project is to be completed in the shortest possible time.

(*d*) Explain, briefly, whether or not the revised project can be completed in the same time as the original project if the duration of activity P is

(i) 10 days

(ii) 17 days

(2)

(Total 11 marks)

5. (i) Draw the activity network described in the precedence table below, using activity on arc and the minimum number of dummies.

Activity	Immediately preceding activities
A	–
B	–
C	–
D	*A, C*
E	*B*
F	*E*
G	*A*
H	*D, F*
I	*D, F*
J	*H, I*

(ii) Explain why each of your dummies is necessary.

(7)

(Total 7 marks)

6.

Activity	Immediately preceding activities
A	–
B	–
C	A
D	A
E	B
F	C D
G	D
H	F G
I	H
J	H
K	I J

(*a*) Draw the activity network described in the precedence table, using activity on arc and exactly two dummies.

(5)

(*b*) Explain why each of the two dummies is necessary.

(2)

(Total 7 marks)

7.

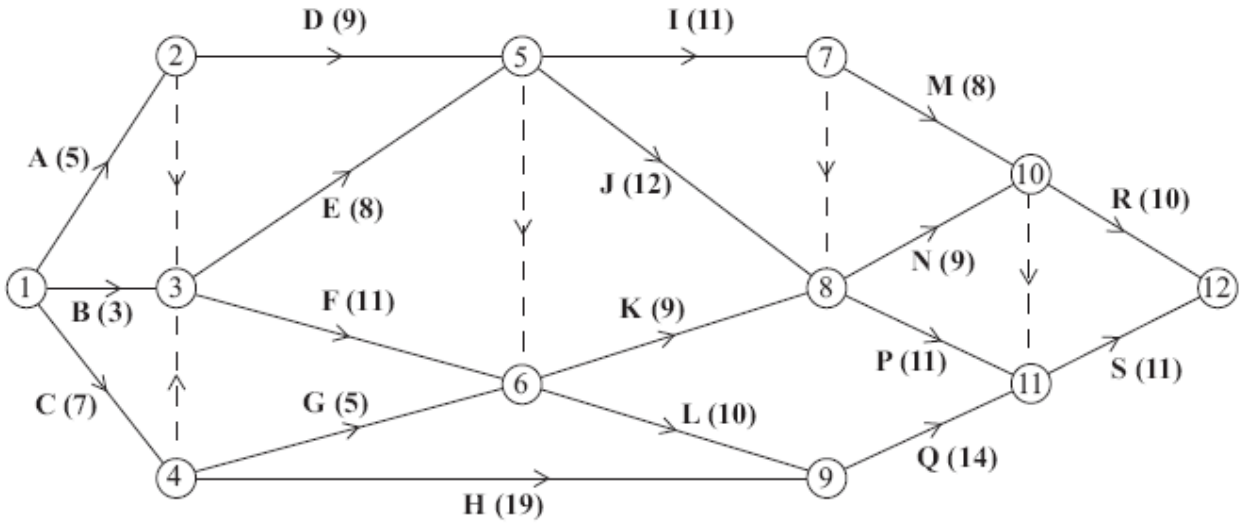

Figure 3

[*The sum of the duration of all activities is 172 days*]

A project is modelled by the activity network shown in Figure 3. The activities are represented by the arcs. The number in brackets on each arc gives the time, in days, to complete the activity. Each activity requires one worker. The project is to be completed in the shortest possible time.

(*a*) Complete Diagram 1 in the answer book to show the early event times and late event times.

(4)

(*b*) Calculate the total float for activity **M**. You must make the numbers you use in your calculation clear.

(2)

(*c*) For each of the situations below, explain the effect that the delay would have on the project completion date.

(i) A 2 day delay on the early start of activity **P**.

(ii) A 2 day delay on the early start of activity **Q**.

(2)

(*d*) Calculate a lower bound for the number of workers needed to complete the project in the shortest possible time.

(1)

Diagram 2 in the answer book shows a partly completed cascade chart for this project.

(*e*) Complete the cascade chart.

(4)

(*f*) Use your cascade chart to determine a second lower bound on the number of workers needed to complete the project in the shortest possible time. You must make specific reference to times and activities.

(2)

(*g*) State which of the two lower bounds found in (*d*) and (*f*) is better. Give a reason for your answer.

(2)

(Total 17 marks)

8.

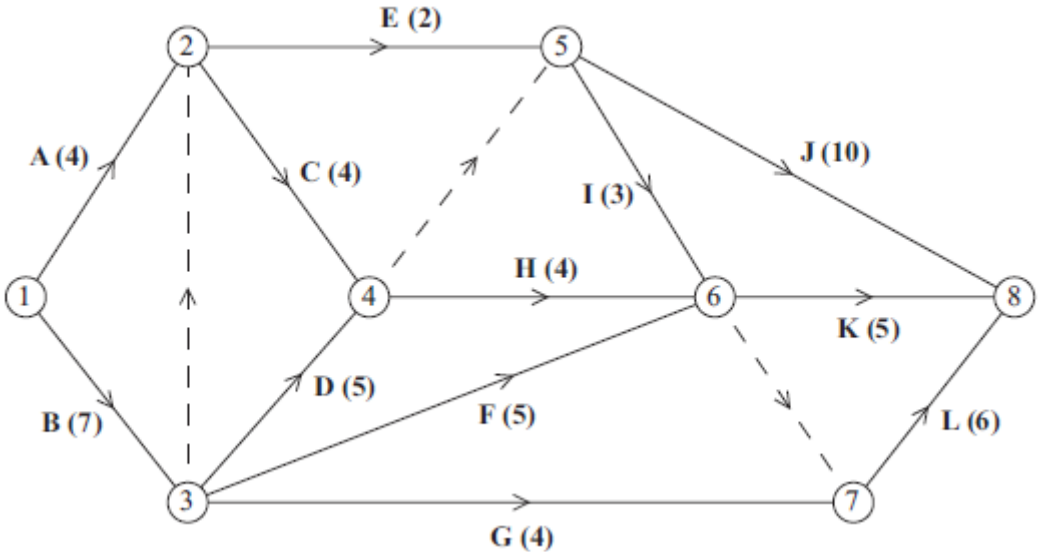

Figure 4

A project is modelled by the activity network shown in Figure 4. The activities are represented by the arcs. The number in brackets on each arc gives the time, in days, to complete the activity. Each activity requires one worker. The project is to be completed in the shortest possible time.

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

(3)

(*b*) Complete Diagram 1 in the answer book, to show the early event times and late event times.

(4)

(*c*) State the critical activities.

(2)

(*d*) On the grid in your answer book, draw a cascade (Gantt) chart for this project.

(4)

(*e*) By considering the activities that must take place between time 7 and time 16, explain why it is not possible to complete this project with just 3 workers in the minimum time.

(3)

(Total 16 marks)

9.

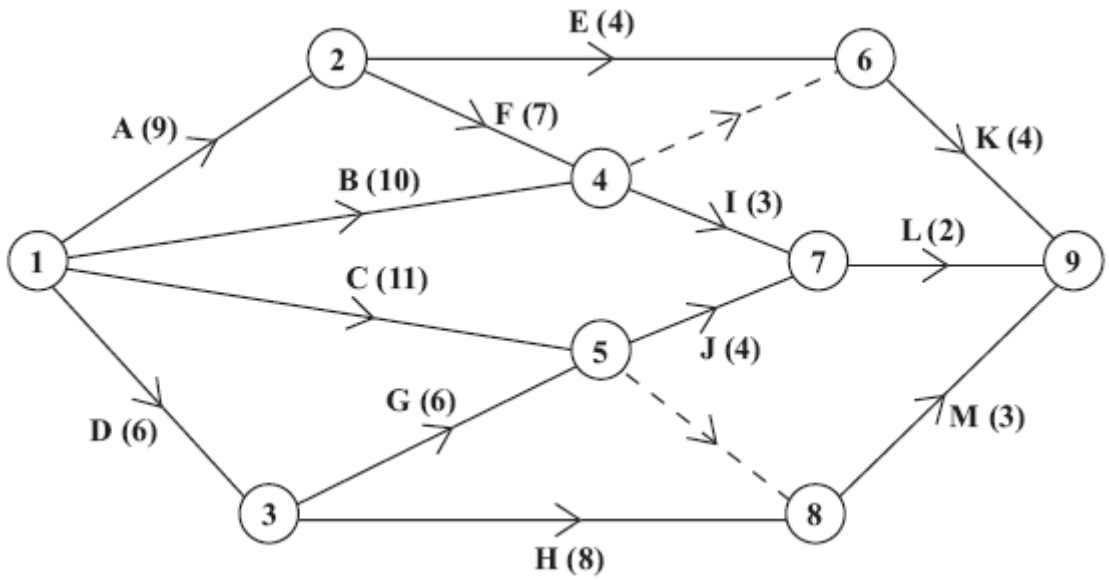

Figure 5

Figure 5 is the activity network relating to a building project. The activities are represented by the arcs. The number in brackets on each arc gives the time to complete the activity. Each activity requires one worker.

The project **must** be completed in the shortest possible time.

(*a*) Explain the reason for the dotted line from event 4 to event 6 as shown in Figure 7.

(2)

(*b*) Complete Diagram 1 in the answer book to show the early event times and the late event times.

(4)

(*c*) State the critical activities.

(1)

(*d*) Calculate the total float for activity **G**. You must make the numbers you use in your calculation clear.

(2)

(*e*) Draw a Gantt chart for this project on the grid provided in the answer book.

(4)

(*f*) State the activities that **must** be happening at time 5.5.

(1)

(*g*) Use your Gantt chart to determine the minimum number of workers needed to complete the project in the minimum time. You must justify your answer.

(2)

(Total 16 marks)

10.

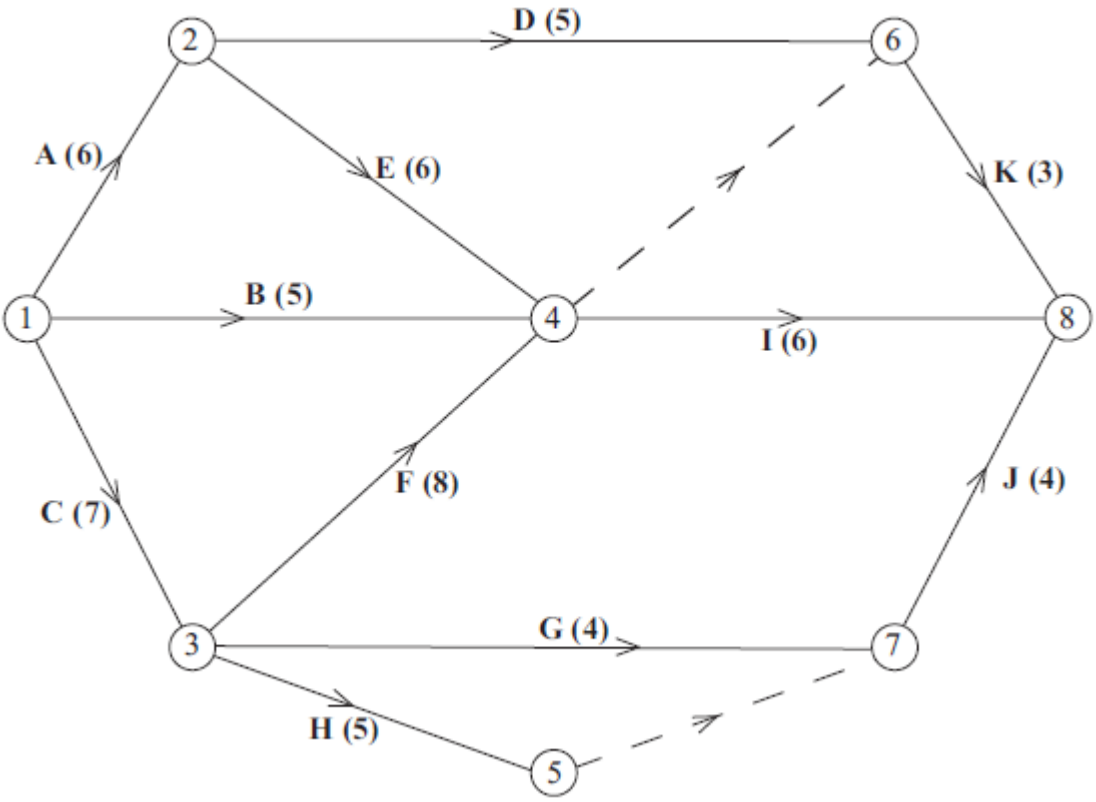

Figure 6

A project is modelled by the activity network shown in Figure 7. The activities are represented by the arcs. The number in brackets on each arc gives the time required, in hours, to complete the activity. The numbers in circles are the event numbers. Each activity requires one worker.

(*a*) Explain the significance of the dummy activity

(i) from event 4 to event 6,

(ii) from event 5 to event 7

(3)

(*b*) Calculate the early time and the late time for each event. Write these in the boxes in the answer book.

(4)

(*c*) Calculate the total float on each of activities **D** and **G**. You must make the numbers you use in your calculations clear.

(3)

(*d*) Calculate a lower bound for the minimum number of workers required to complete the project in the minimum time.

(2)

(*e*) On the grid in your answer book, draw a cascade (Gantt) chart for this project.

(4)

(Total 16 marks)

11.

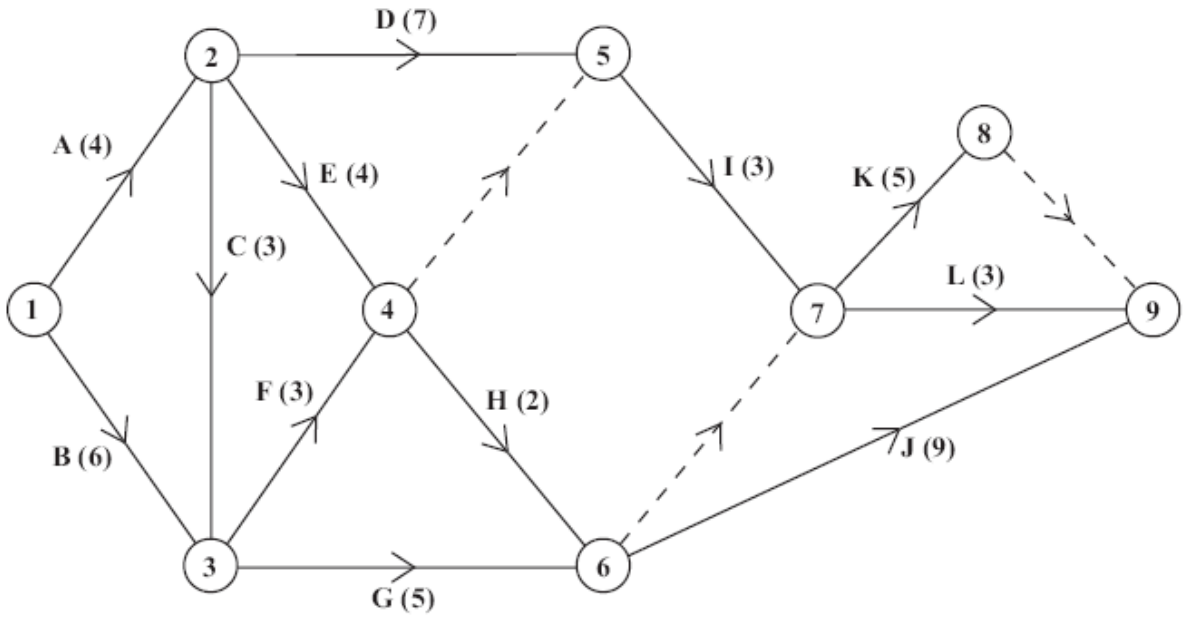

Figure 7

The network in Figure 7 shows the activities that need to be undertaken to complete a maintenance project. The activities are represented by the arcs. The number in brackets on each arc gives the time, in days, to complete the activity. The numbers in circles are the events.

Each activity requires one worker. The project is to be completed in the shortest possible time.

(*a*) Complete the precedence table for this network in the answer book.

(3)

(*b*) Explain why each of the following is necessary.

(i) The dummy from event 6 to event 7.

(ii) The dummy from event 8 to event 9.

(3)

(*c*) Complete Diagram 2 in the answer book to show the early and the late event times.

(4)

(*d*) State the critical activities.

(2)

(*e*) Calculate the total float on activity **K**. You **must** make the numbers used in your calculation clear.

(2)

(*f*) Calculate a lower bound for the number of workers needed to complete the project in the minimum time.

(2)

(Total 16 marks)

TOTAL FOR PAPER: 130 MARKS

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Critical path analysis

Answer Book
Do not return the question paper with the answer book.

Total Marks

1.

(Total 5 marks)

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2. (*a*)

Question 2 continued

(*b*)

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(Total 7 marks)

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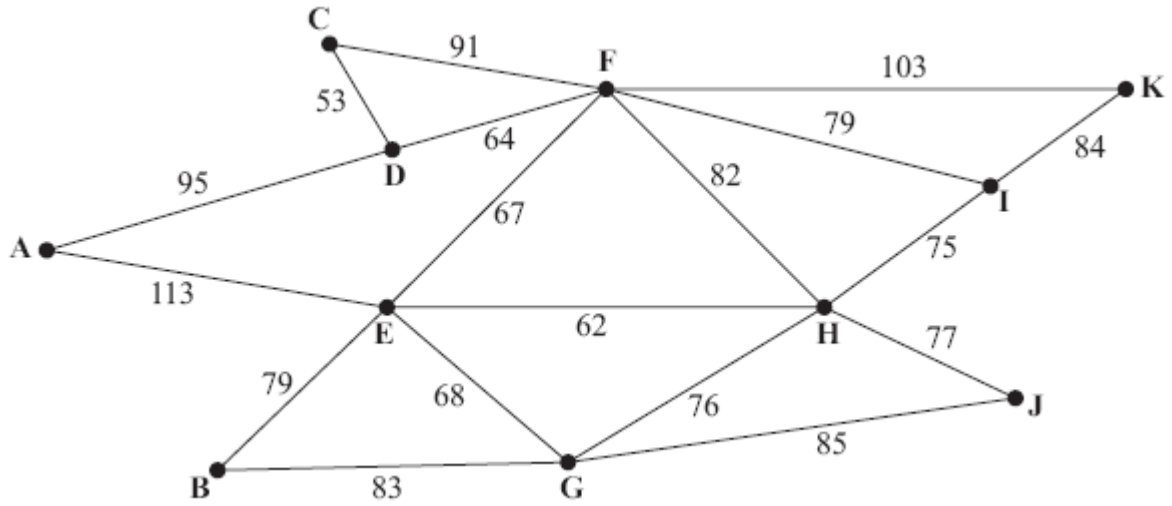

Figure 1

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Question 3 continued

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(Total 12 marks)

4. (a)

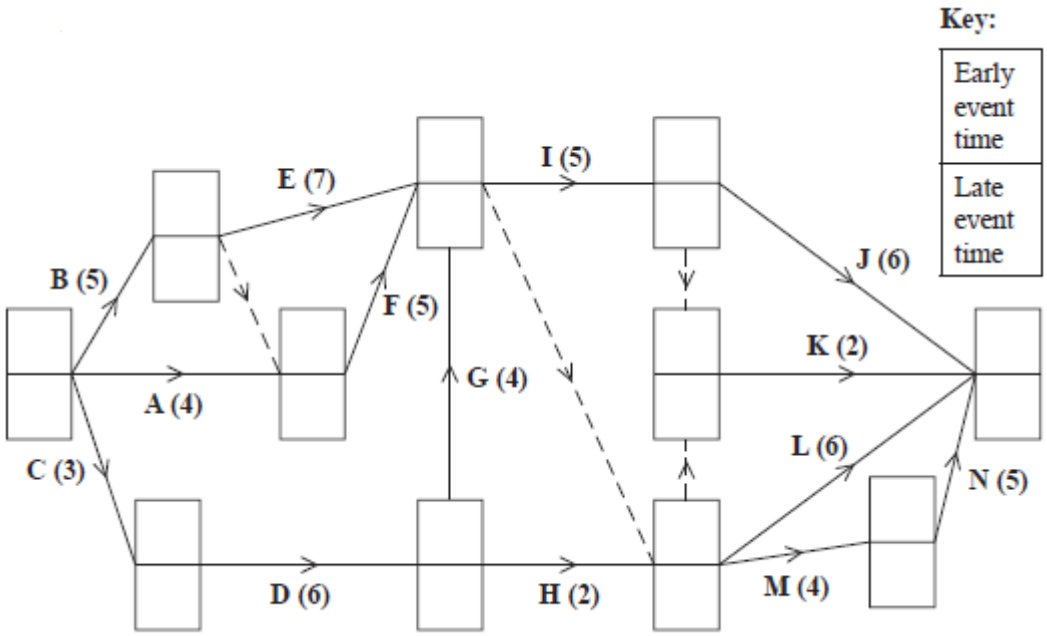
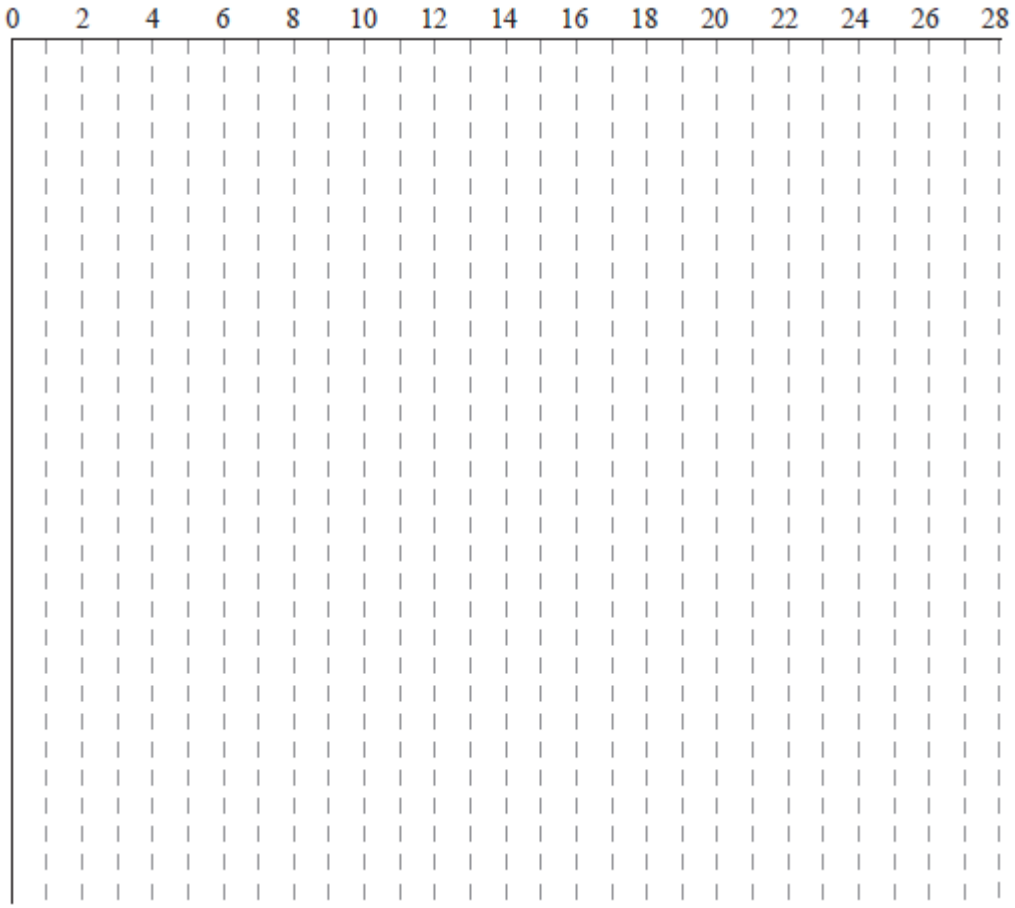


Diagram 1

(b)



Question 4 continued

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(2)

(Total 11 marks)

5.

Turn over

Question 5 continued

(Total 7 marks)

6.

Turn over

Question 6 continued

(Total 7 marks)

Turn over

7. (a)

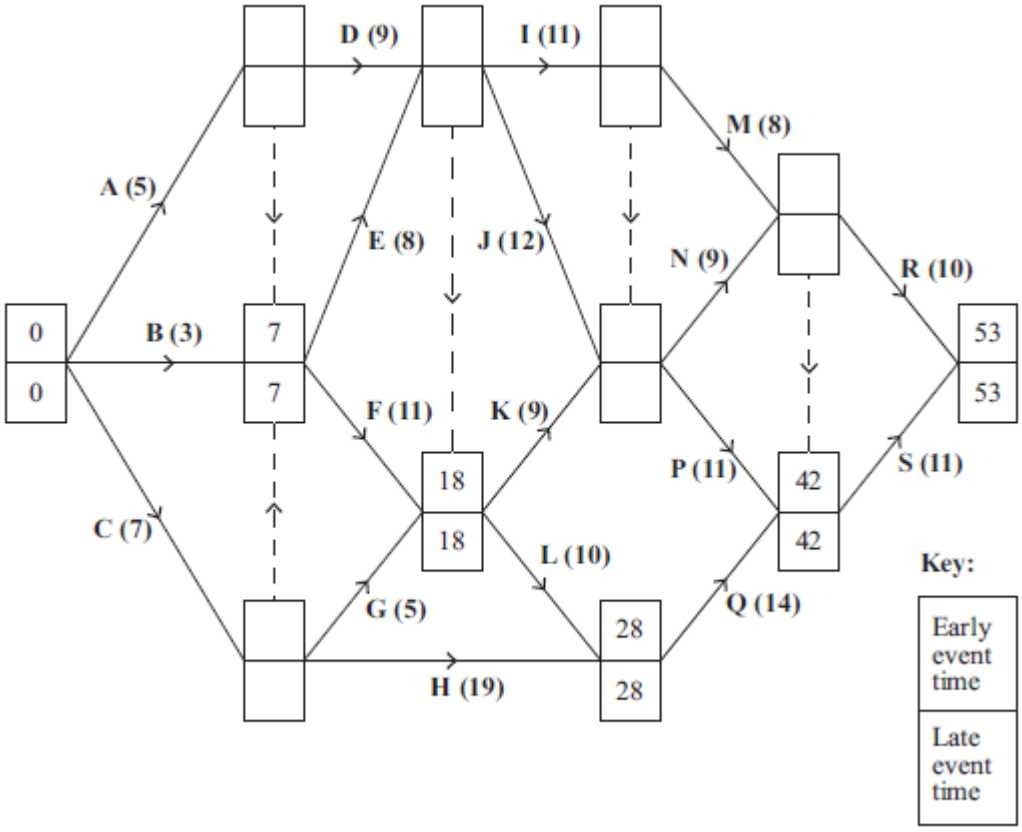

Diagram 1

(b) ……..……..

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(c) ……..

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(d) ……..……..

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Question 7 continued

(e)

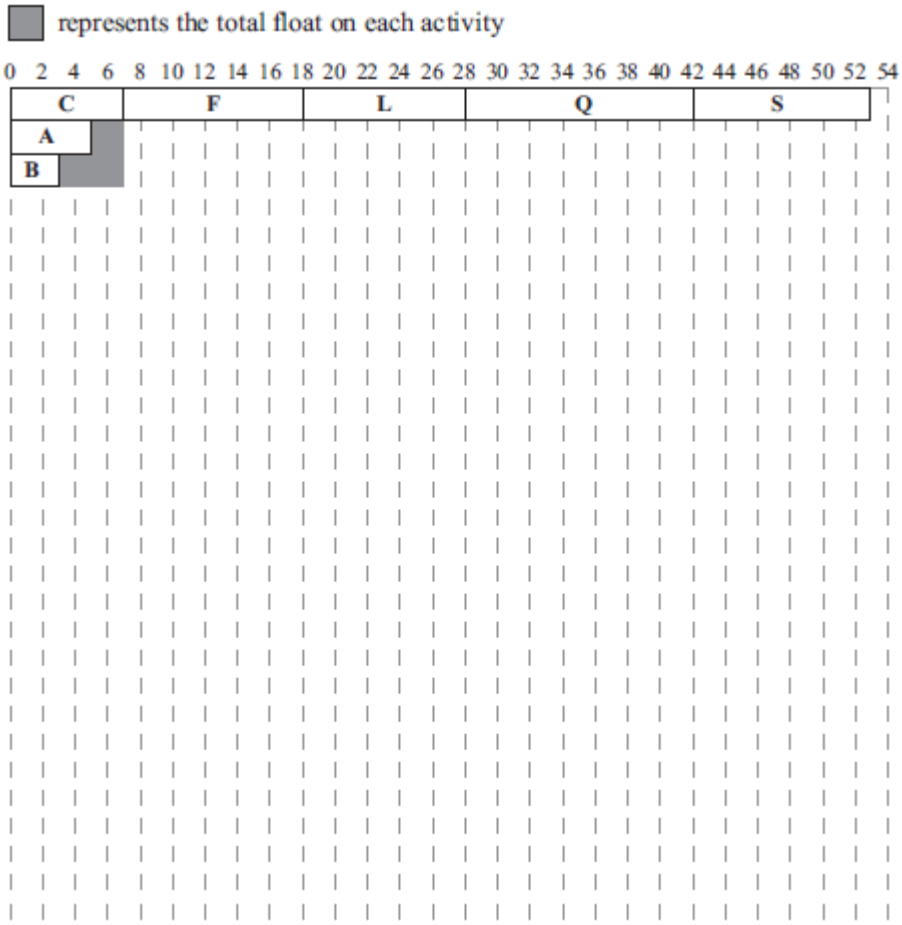

Diagram 2

(f) ……..……..

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(g) ……..……..

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(Total 17 marks)

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8. (a)

Activity	Proceeded by		Activity	Proceeded by		Activity	Proceeded by
A	**-**		**E**			**I**	
B	**-**		**F**	**B**		**J**	
C			**G**	**B**		**K**	
D	**B**		**H**			**L**	

(b)

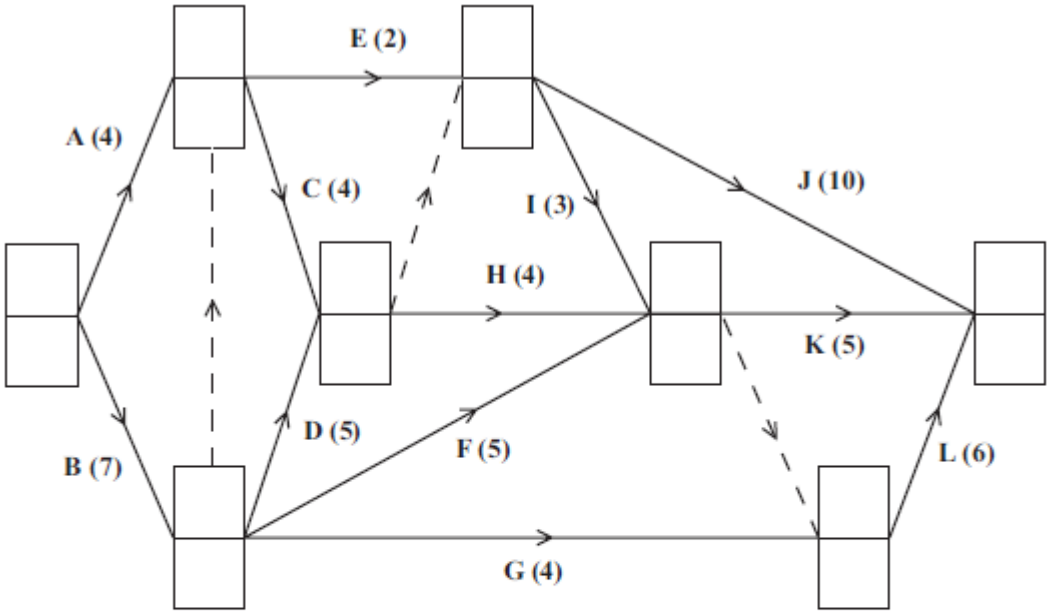

Diagram 1

Key:

Early event time
Late event time

Question 8 continued

(c) ……..……..

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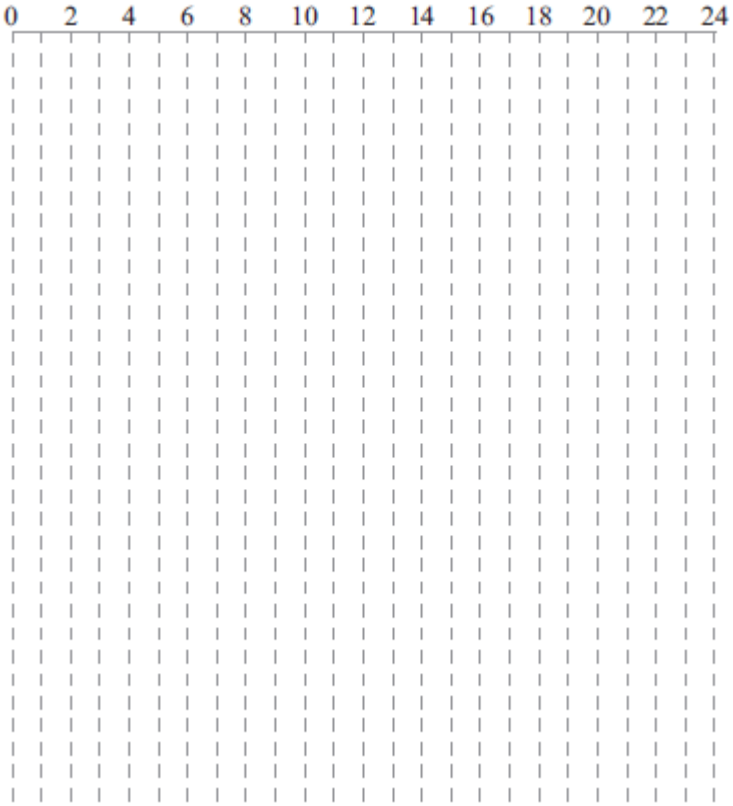
(d)



(e) ……..……..

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(Total 16 marks)

9.

(a) ……..……..

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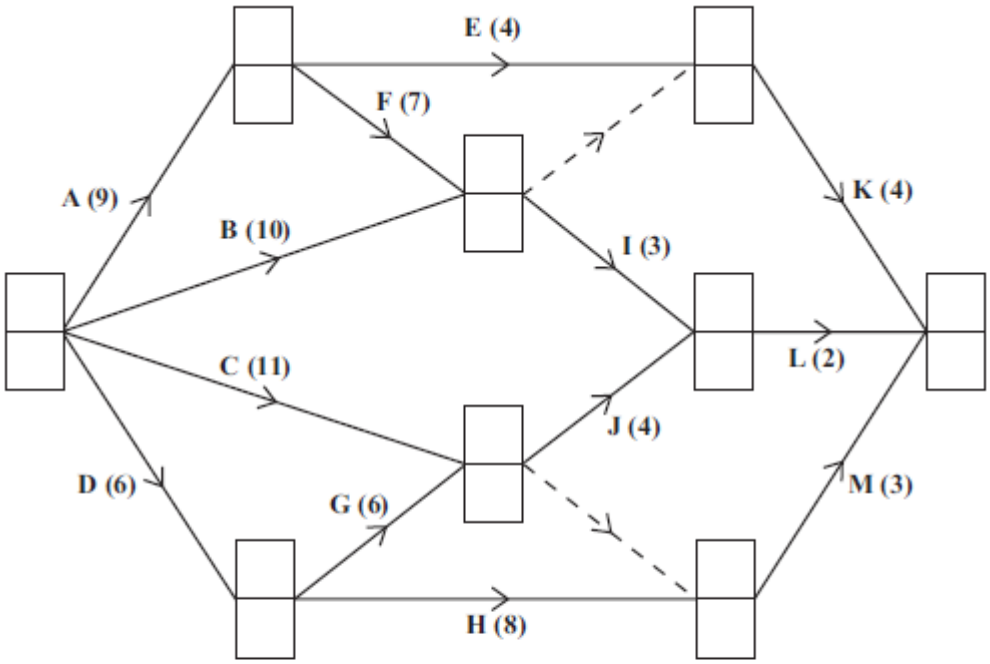
(b)



Key:

Early event time
Late event time

Diagram 1

Question 9 continued

(c) Critical activities ……..……..

(d) …..……..

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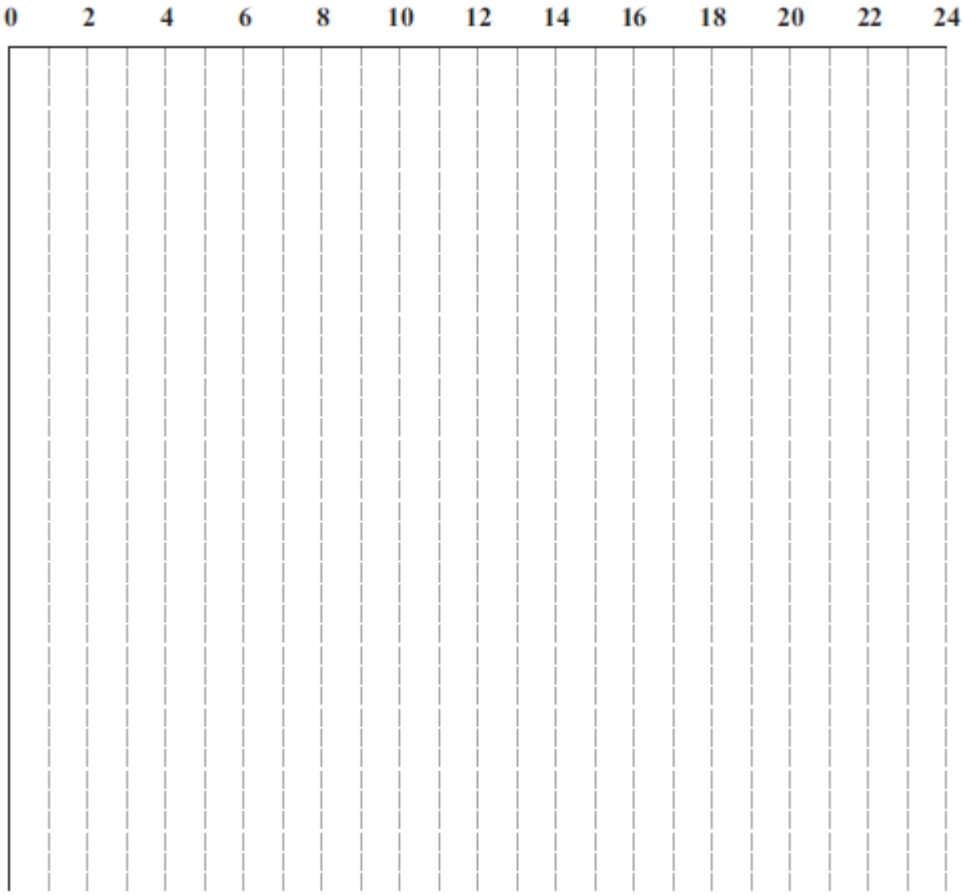
(e)



(f) Activities that must be happening at time 5.5 ……..……..

(g) …..……..

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(Total 16 marks)

10.

(a) (i) ……..……..

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(a) (ii) ...……..……..

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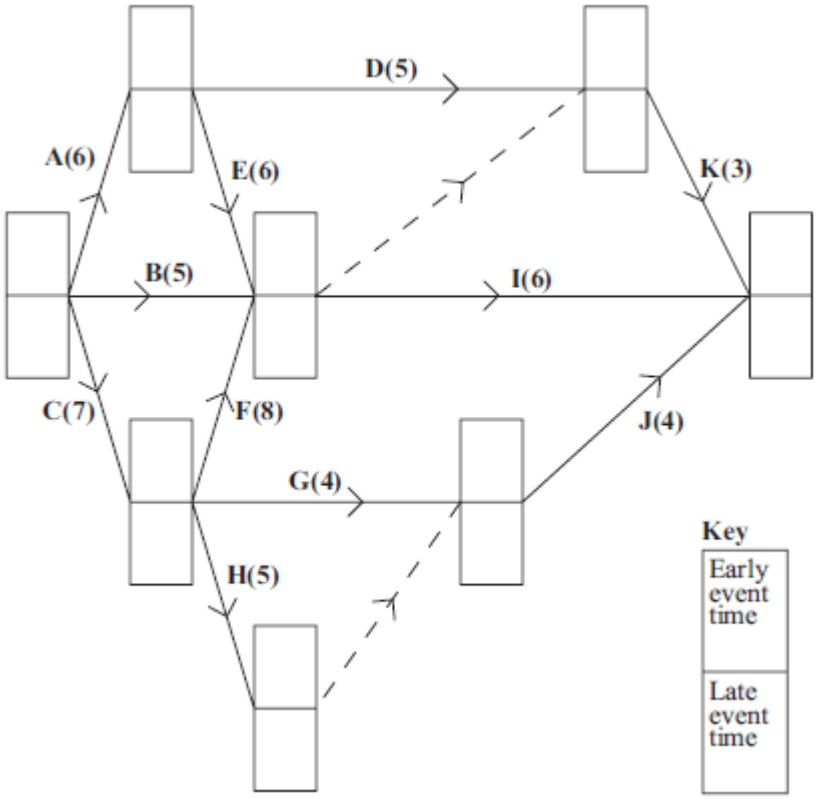
(b)


D(5)
A(6)
E(6)
K(3)
B(5)
I(6)
C(7)
F(8)
J(4)
G(4)
H(5)
Key
Early event time
Late event time

(c) ….....……..……..

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Question 10 continued

(d) ……

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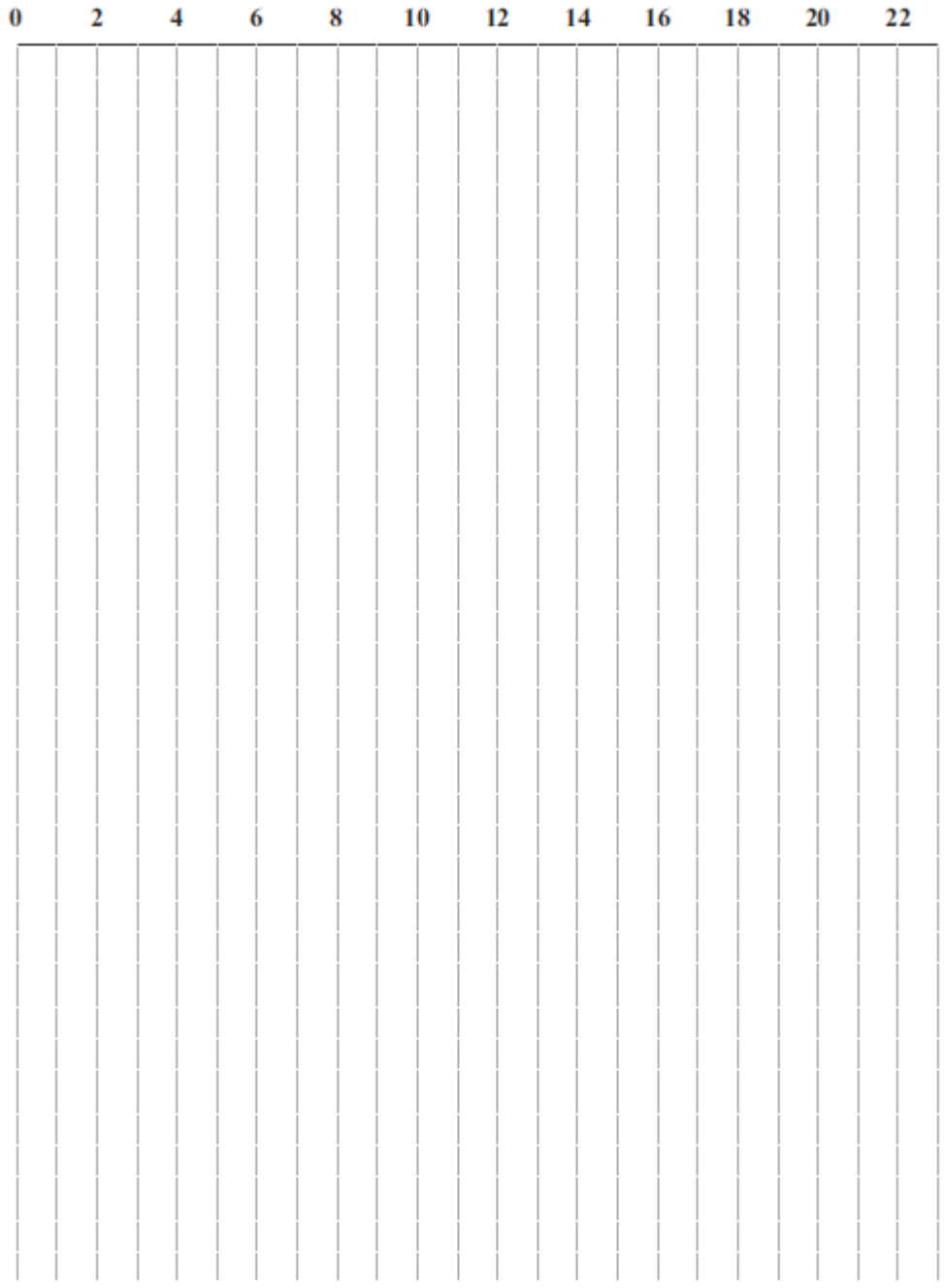
(e)



Question 10 continued

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(Total 16 marks)

11. (a)

Activity	Immediately preceding activities
A	-
B	-
C	A
D	A
E	B, C
F	
G	
H	
I	
J	
K	
L	

Precedence table

(b)

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Question 11 continued

(c)

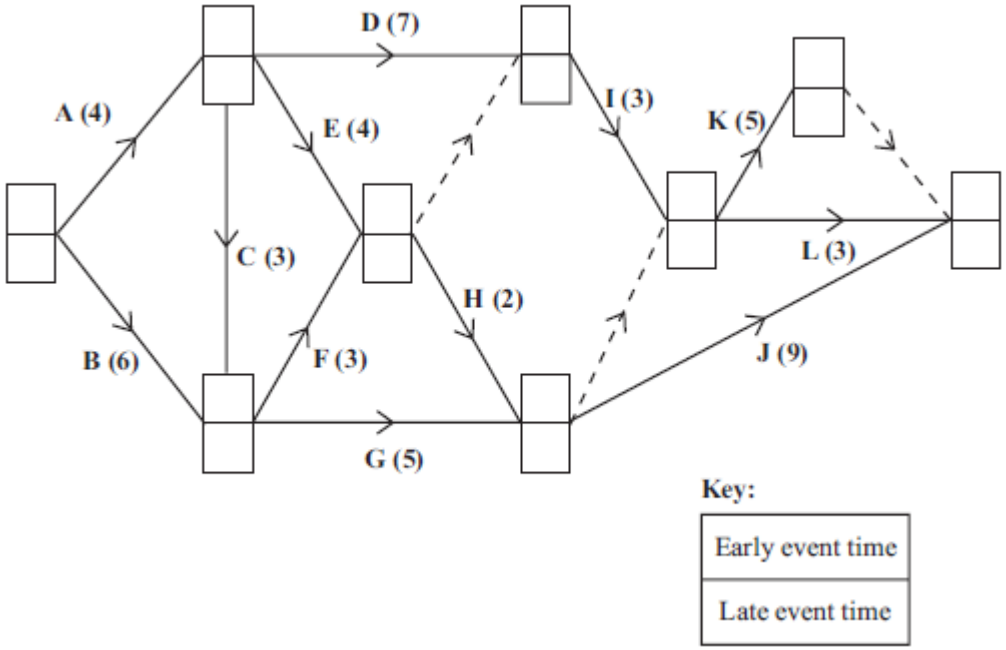

Diagram 2

(d) Critical activities …..……..

(e) …..……..

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(f) ...……..

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(Total 16 marks)

TOTAL FOR PAPER: 130 MARKS

Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Linear programming

You must have:
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

Instructions

- Use black ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- Fill in the boxes at the top of this page with your name, centre number and candidate number.
- Answer all the 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

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 100.
- The marks for each question are shown in brackets – use this as a guide as to how much time to spend on each question.
- Calculators must not be used for questions marked with a * sign.

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.

1.

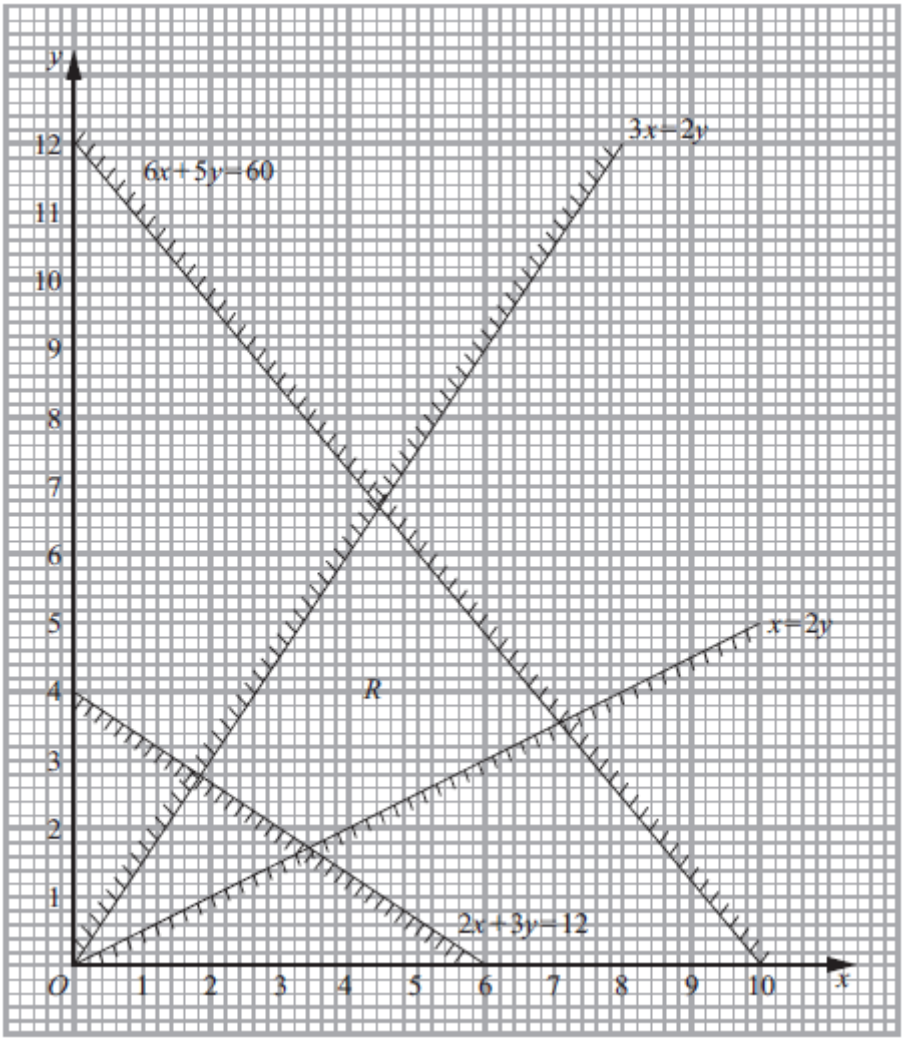

Figure 1

Figure 1 shows the constraints of a linear programming problem in x and y, where R is the feasible region.

(a) Write down the inequalities that form region R.

(2)

The objective is to maximise $3x + y$.

(b) Find the optimal values of x and y. You must make your method clear.

(4)

(c) Obtain the optimal value of the objective function.

(1)

Given that integer values of x and y are now required,

(*d*) write down the optimal values of x and y.

(1)

(Total 8 marks)

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

Maximise $P = 2x + 3y$

subject to

$$x \geq 25$$

$$y \geq 25$$

$$7x + 8y \leq 840$$

$$4y \leq 5x$$

$$5y \geq 3x$$

$$x, y \geq 0$$

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

(3)

(*c*) Calculate the exact coordinates of vertex V.

(2)

Given that an integer solution is required,

(*d*) determine the optimal solution with integer coordinates. You must make your method clear.

(2)

(Total 11 marks)

3.

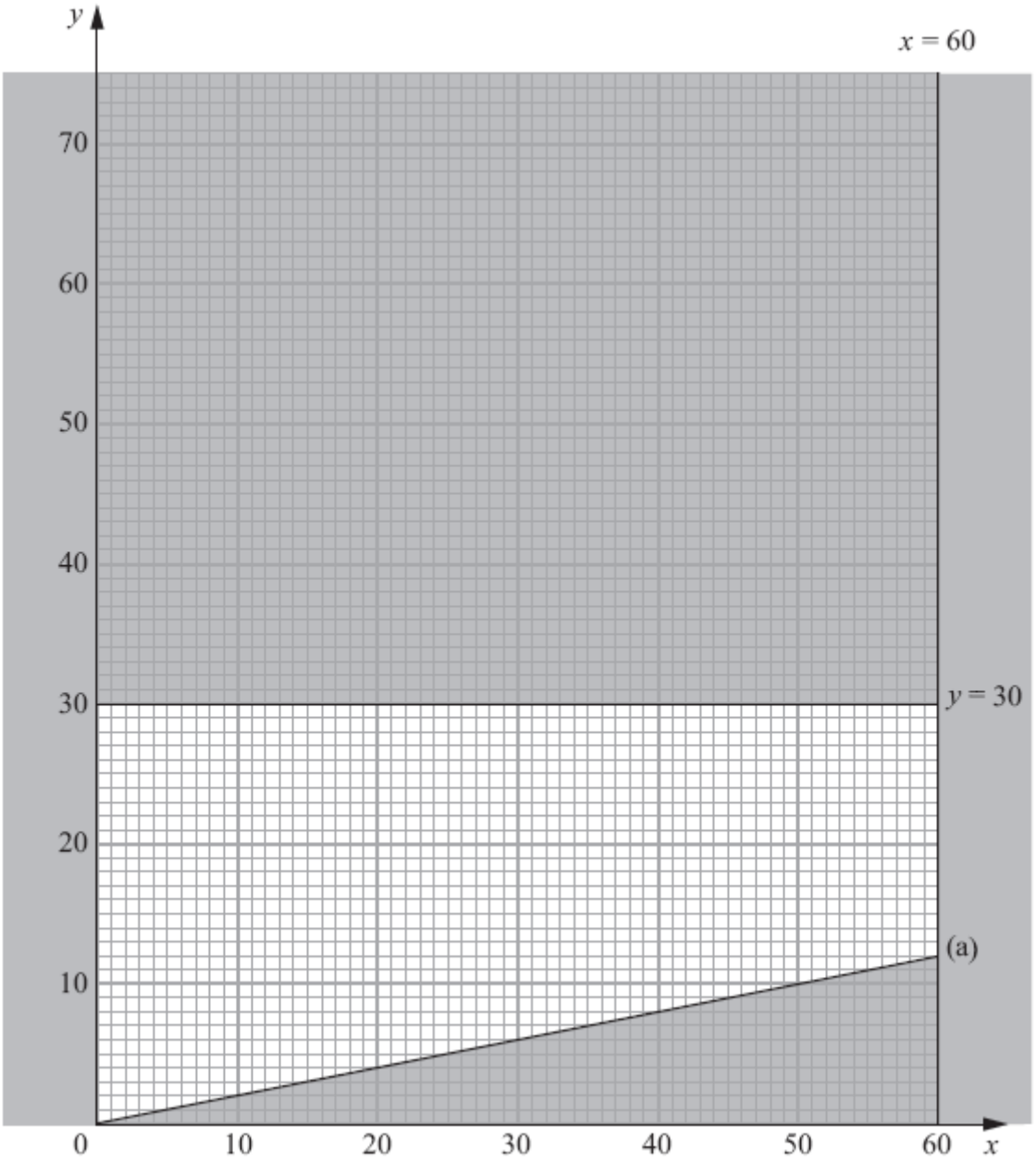


Figure 2

Lethna is producing floral arrangements for an awards ceremony.

She will produce two types of arrangement, Celebration and Party.

Let x be the number of Celebration arrangements made.

Let y be the number of Party arrangements made.

Figure 2 shows three constraints, other than $x, y \geq 0$.

The rejected region has been shaded.

Given that two of the three constraints are $y \leq 30$ and $x \leq 60$,

(*a*) write down, as an inequality, the third constraint shown in Figure 6.

(2)

Each Celebration arrangement includes 2 white roses and 4 red roses.

Each Party arrangement includes 1 white rose and 5 red roses.

Lethna wishes to use at least 70 white roses and at least 200 red roses.

(*b*) Write down two further inequalities to represent this information.

(3)

(*c*) Add two lines and shading to Diagram 1 in the answer book to represent these two inequalities.

(2)

(*d*) Hence determine the feasible region and label it R.

(1)

The times taken to produce each Celebration arrangement and each Party arrangement are 10 minutes and 4 minutes respectively. Lethna wishes to minimise the total time taken to produce the arrangements.

(*e*) Write down the objective function, T, in terms of x and y.

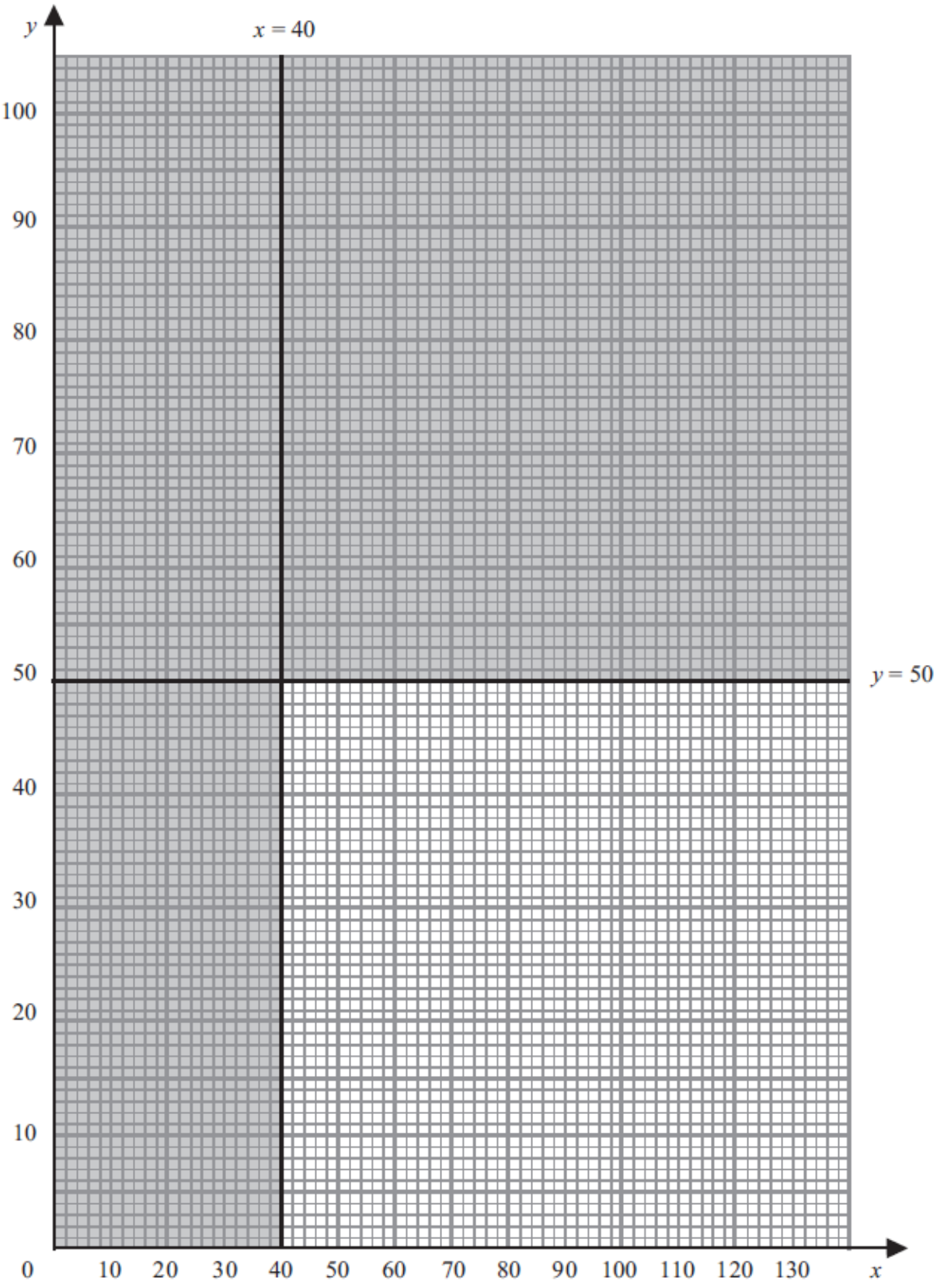
(1)

(*f*) Use point testing to find the optimal number of each type of arrangement Lethna should produce, and find the total time she will take.

(4)

(Total 13 marks)

4.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130
x

Figure 3

Edgar has recently bought a field in which he intends to plant apple trees and plum trees.

He can use linear programming to determine the number of each type of tree he should plant.

Let x be the number of apple trees he plants and y be the number of plum trees he plants.

Two of the constraints are

$$x \geq 40$$

$$y \leq 50$$

These are shown on the graph in Figure 3, where the rejected region is shaded out.

(*a*) Use these two constraints to write down two statements that describe the number of apple trees and plum trees Edgar can plant.

(1)

Two further constraints are

$$3x + 4y \leq 360$$

$$x \leq 2y$$

(*b*) Add two lines and shading to Diagram 1 in your answer book to represent these inequalities. Hence determine the feasible region and label it R.

(4)

Edgar will make a profit of £60 from each apple tree and £20 from each plum tree. He wishes to maximise his profit, P.

(*c*) Write down the objective function.

(1)

(*d*) Use an objective line to determine the optimal point of the feasible region, R. You must make your method clear.

(4)

(*e*) Find Edgar's maximum profit.

(1)

(Total 11 marks)

5.

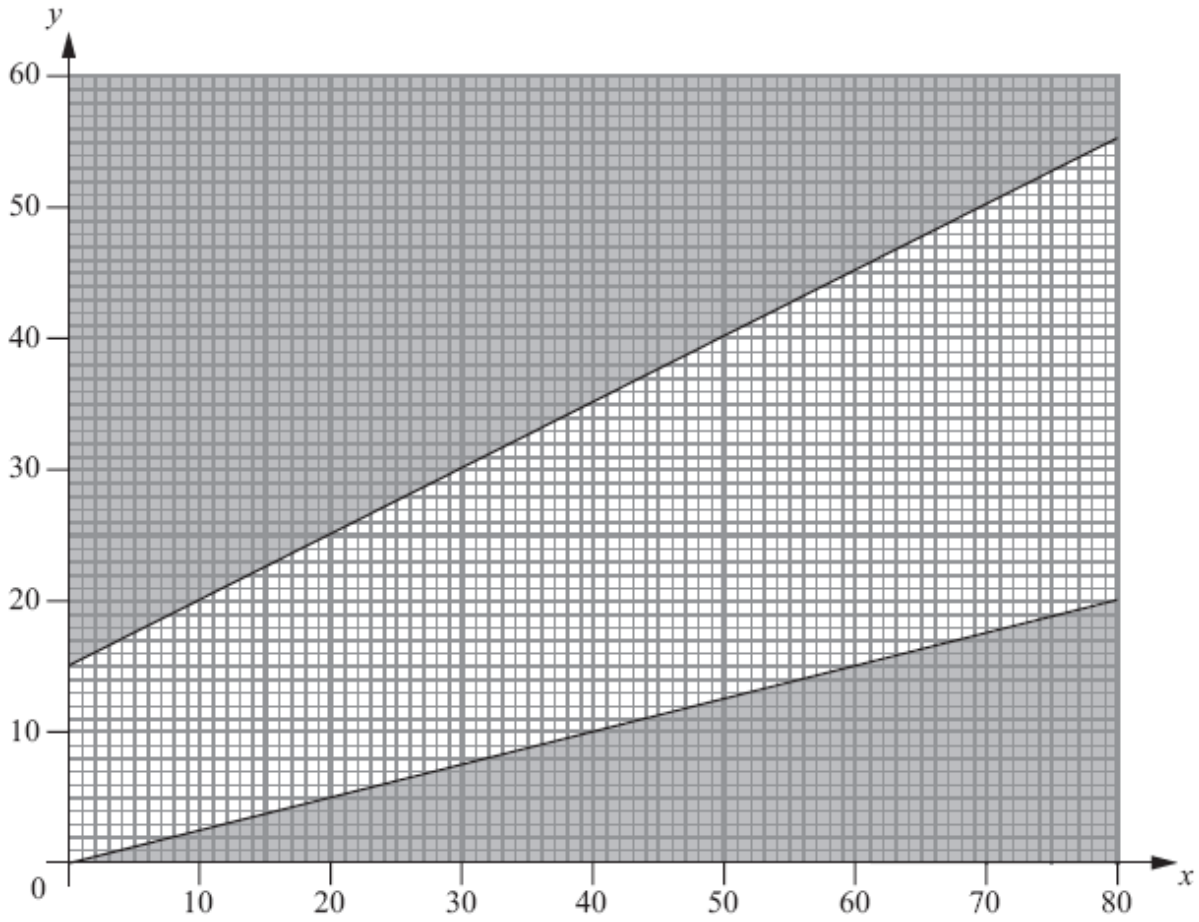

Figure 4

The graph in Figure 4 is being used to solve a linear programming problem.

Two of the constraints have been drawn on the graph and the rejected regions shaded out.

(*a*) Write down the constraints shown on the graph.

(4)

Two further constraints are

$$x + y \geq 30$$

and $\quad 5x + 8y \leq 400$

(*b*) Add two lines and shading to Graph 1 **in your answer book** to represent these constraints. Hence determine the feasible region and label it *R*.

(4)

The objective is to

$$\text{minimise } 15x + 10y.$$

(*c*) Draw a profit line on Graph 1 and use it to find the optimal solution. You must label your profit line clearly.

(3)

(Total 11 marks)

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6. A caterer can make three different sizes of salad; small, medium and large.

The caterer will make a total of at least 280 salads.

The caterer wants at least 35% of the salads to be small and no more than 20% of the salads to be large.

The caterer has enough ingredients to make 400 small salads or 300 medium salads or 200 large salads.

The profit on each small, medium and large salad is 40p, 60p and 85p respectively. The caterer wants to maximise his total profit.

Let x represent the number of small salads, y represent the number of medium salads and z represent the number of large salads.

Formulate this information as a linear programming problem, stating the objective and listing the constraints as simplified inequalities with integer coefficients.

You should **not** attempt to solve the problem.

(Total 8 marks)

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7. Charlie needs to buy storage containers.

There are two different types of storage container available, standard and deluxe.

Standard containers cost £20 and deluxe containers cost £65. Let x be the number of standard containers and y be the number of deluxe containers.

The maximum budget available is £520.

(*a*) Write down an inequality, in terms of x and y, to model this constraint.

(1)

Three further constraints are:

$x \geq 2$

$-x + 24y \geq 24$

$7x + 8y \leq 112$

(*b*) Add lines and shading to Diagram 1 in the answer book to represent all four constraints. Hence determine the feasible region and label it R.

(4)

The capacity of a deluxe container is 50% greater than the capacity of a standard container. Charlie wishes to maximise the total capacity.

(*c*) State an objective function, in terms of x and y.

(1)

(*d*) Use the objective line method to find the optimal vertex, V, of the feasible region. You must make your objective line clear and label the optimal vertex V.

(3)

(*e*) Calculate the exact coordinates of vertex V.

(2)

(*f*) Determine the number of each type of container that Charlie should buy. You must make your method clear and calculate the cost of purchasing the storage containers.

(3)

(Total 14 marks)

8.

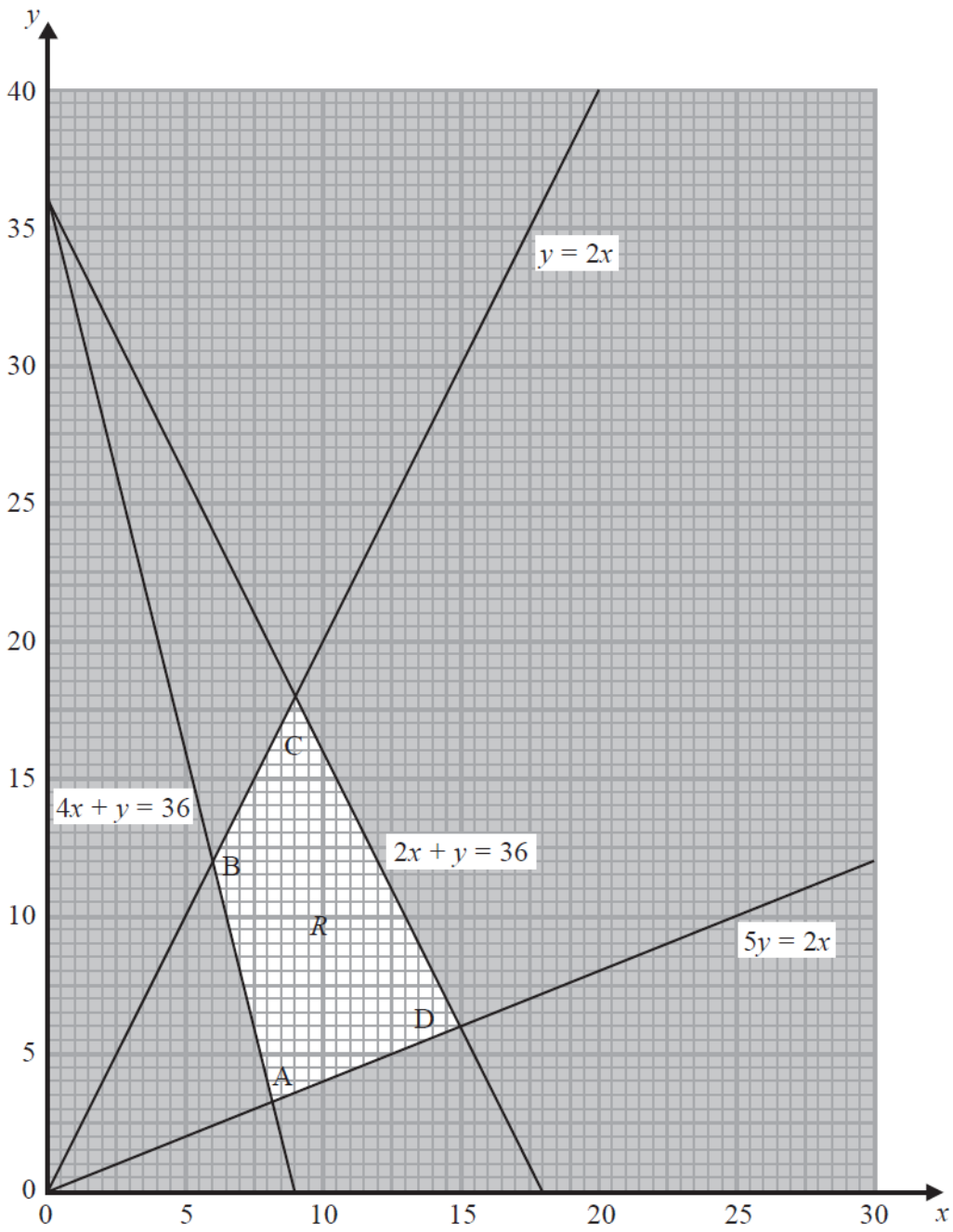

Figure 5

The graph in Figure 5 is being used to solve a linear programming problem. The four constraints have been drawn on the graph and the rejected regions have been shaded out. The four vertices of the feasible region *R* are labelled A, B, C and D.

(*a*) Write down the constraints represented on the graph.

(2)

The objective function, P, is given by

$$P = x + ky$$

where k is a positive constant.

The minimum value of the function P is given by the coordinates of vertex A **and** the maximum value of the function P is given by the coordinates of vertex D.

(*b*) Find the range of possible values for k. You must make your method clear.

(6)

(Total 8 marks)

9.

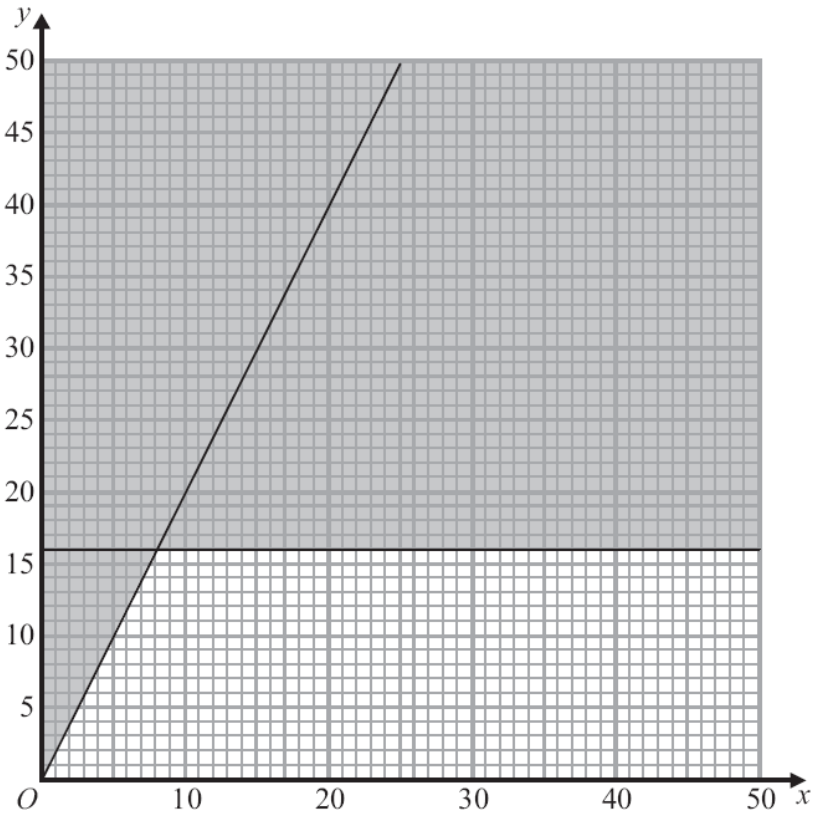

Figure 6

A company makes two types of garden bench, the 'Rustic' and the 'Contemporary'. The company wishes to maximise its profit and decides to use linear programming.

Let x be the number of 'Rustic' benches made each week and y be the number of 'Contemporary' benches made each week.

The graph in Figure 6 is being used to solve this linear programming problem.

Two of the constraints have been drawn on the graph and the rejected region shaded out.

(*a*) Write down the constraints shown on the graph giving your answers as inequalities in terms of x and y.

(3)

It takes 4 working hours to make one 'Rustic' bench and 3 working hours to make one 'Contemporary' bench. There are 120 working hours available in each week.

(*b*) Write down an inequality to represent this information.

(2)

Market research shows that 'Rustic' benches should be at most $\frac{3}{4}$ of the total benches made each week.

(*c*) Write down, and simplify, an inequality to represent this information. Your inequality must have integer coefficients.

(2)

(*d*) Add two lines and shading to Diagram 1 in your answer book to represent the inequalities of (*b*) and (*c*). Hence determine and label the feasible region, R.

(3)

The profit on each 'Rustic' bench and each 'Contemporary' bench is £45 and £30 respectively.

(*e*) Write down the objective function, P, in terms of x and y.

(1)

(*f*) Determine the coordinates of each of the vertices of the feasible region and hence use the vertex method to determine the optimal point.

(4)

(*g*) State the maximum weekly profit the company could make.

(1)

(Total 16 marks)

TOTAL FOR PAPER: 100 MARKS

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | | | | | |

Candidate Number | | | | |

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Linear programming

Answer Book
Do not return the question paper with the answer book.

Total Marks

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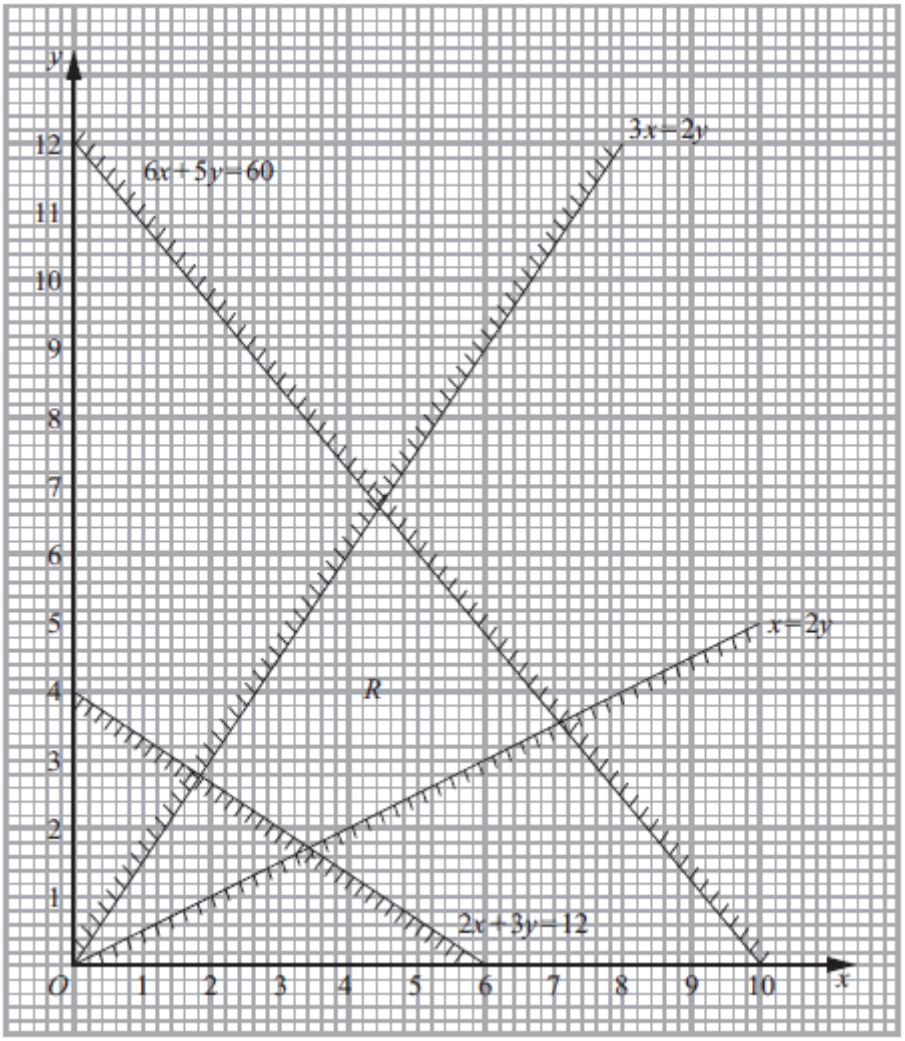

Figure 1

Question 1 continued

(Total 8 marks)

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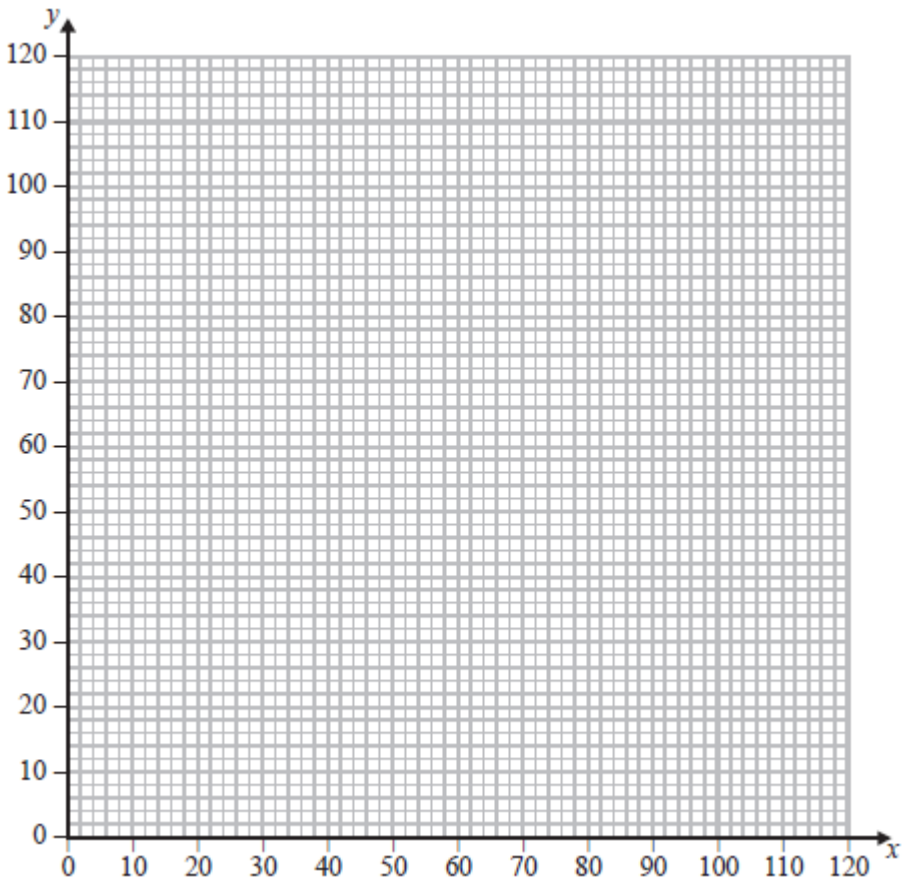
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Diagram 1

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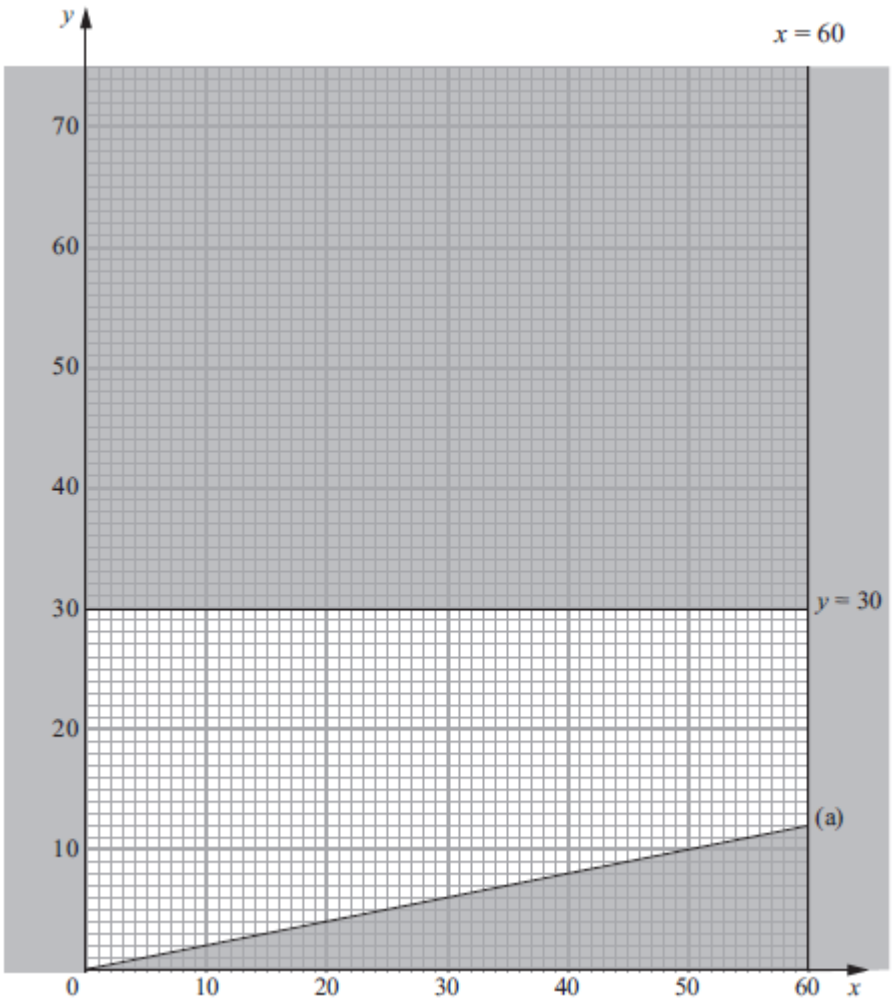

Diagram 1

Question 3 continued

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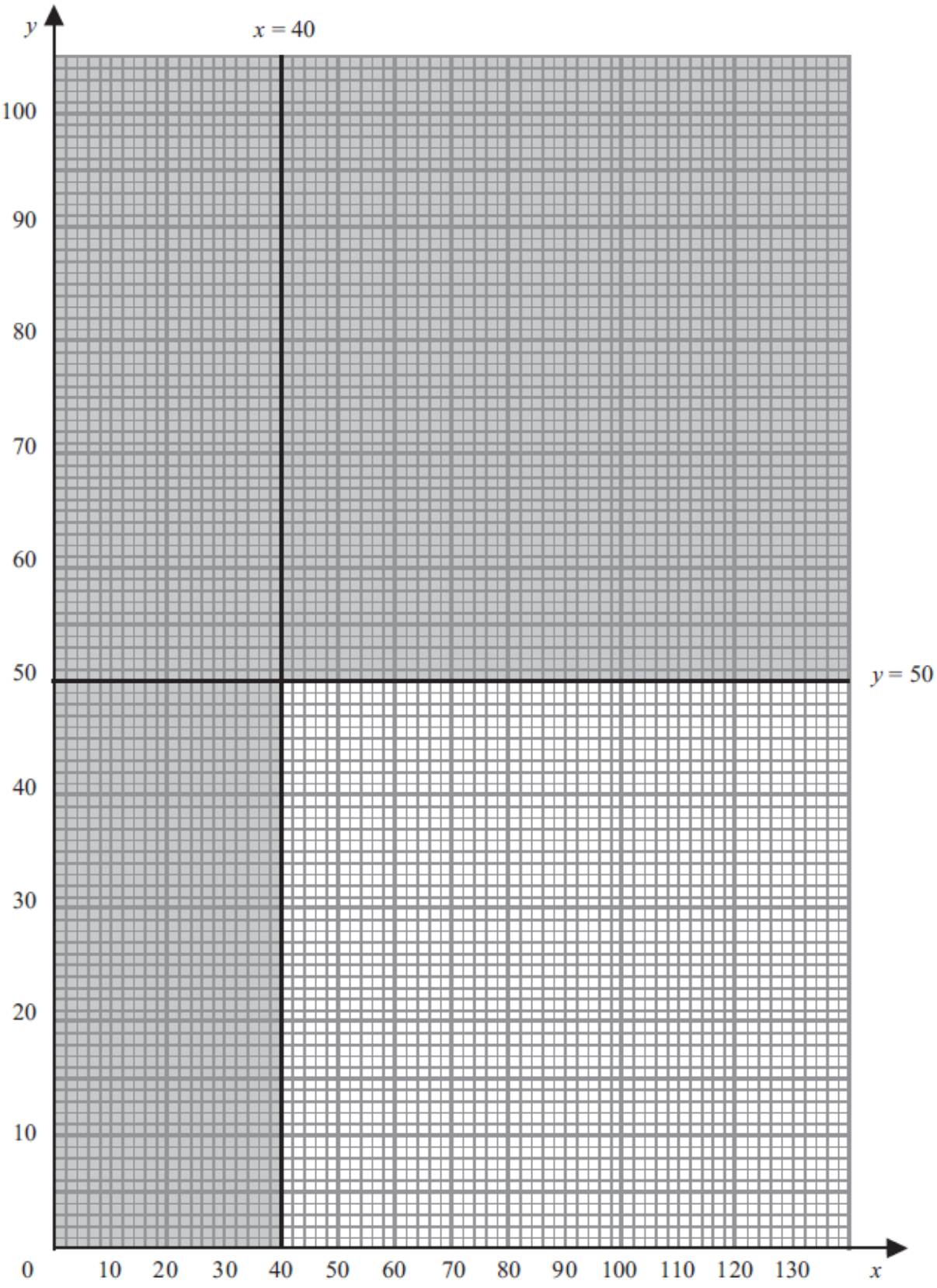
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Diagram 1

Question 4 continued

Question 4 continued

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Question 4 continued

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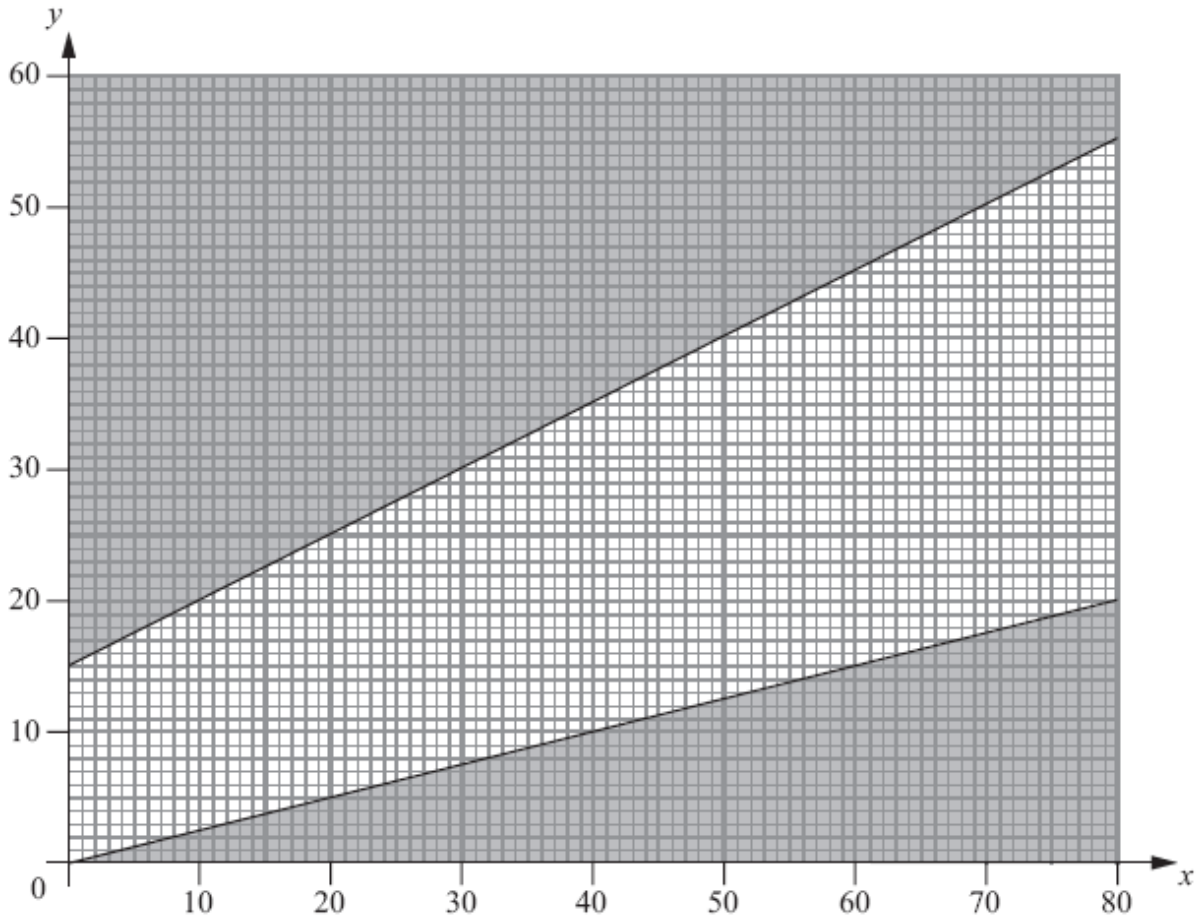

Graph 1

Question 5 continued

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Question 6 continued

(Total 8 marks)

Turn over

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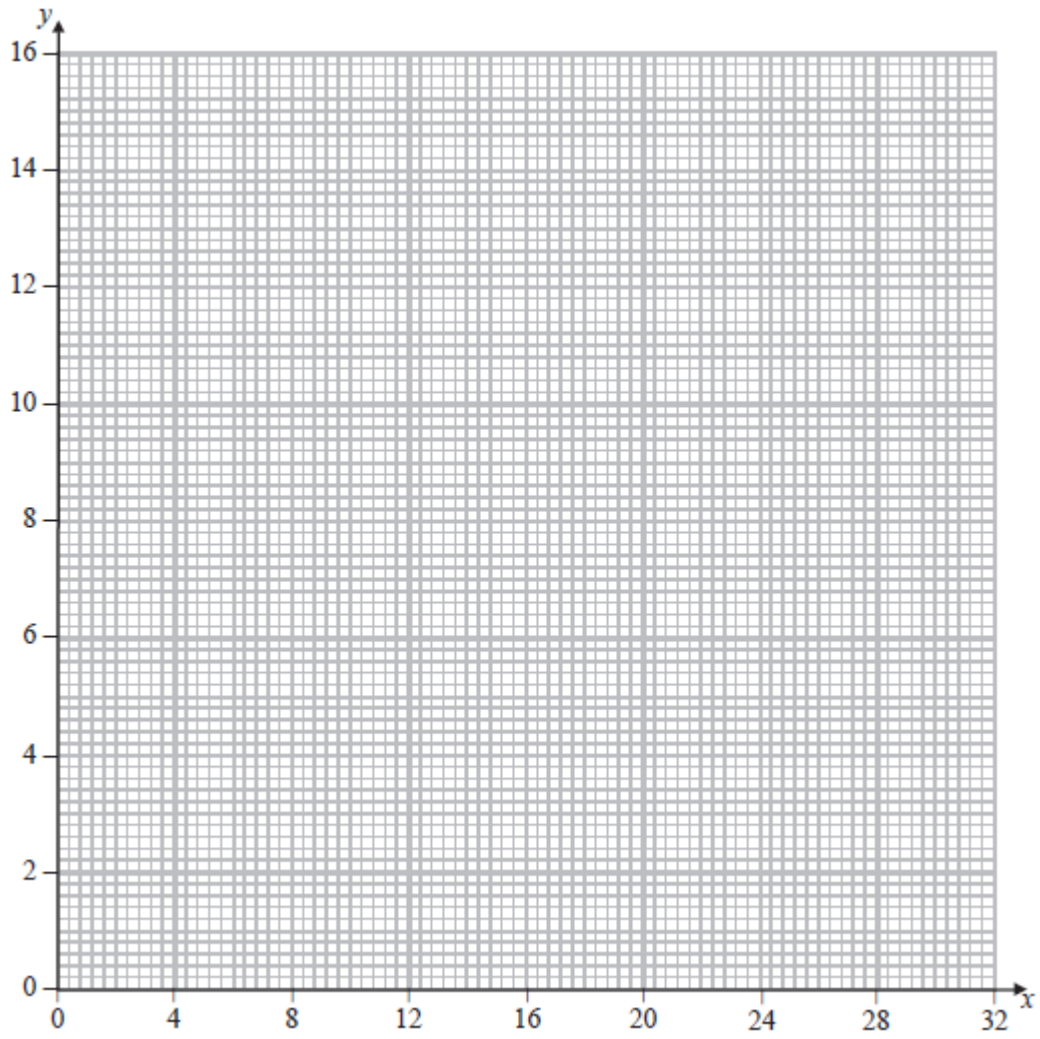

Diagram 1

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Question 7 continued

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Question 7 continued

(Total 14 marks)

Turn over

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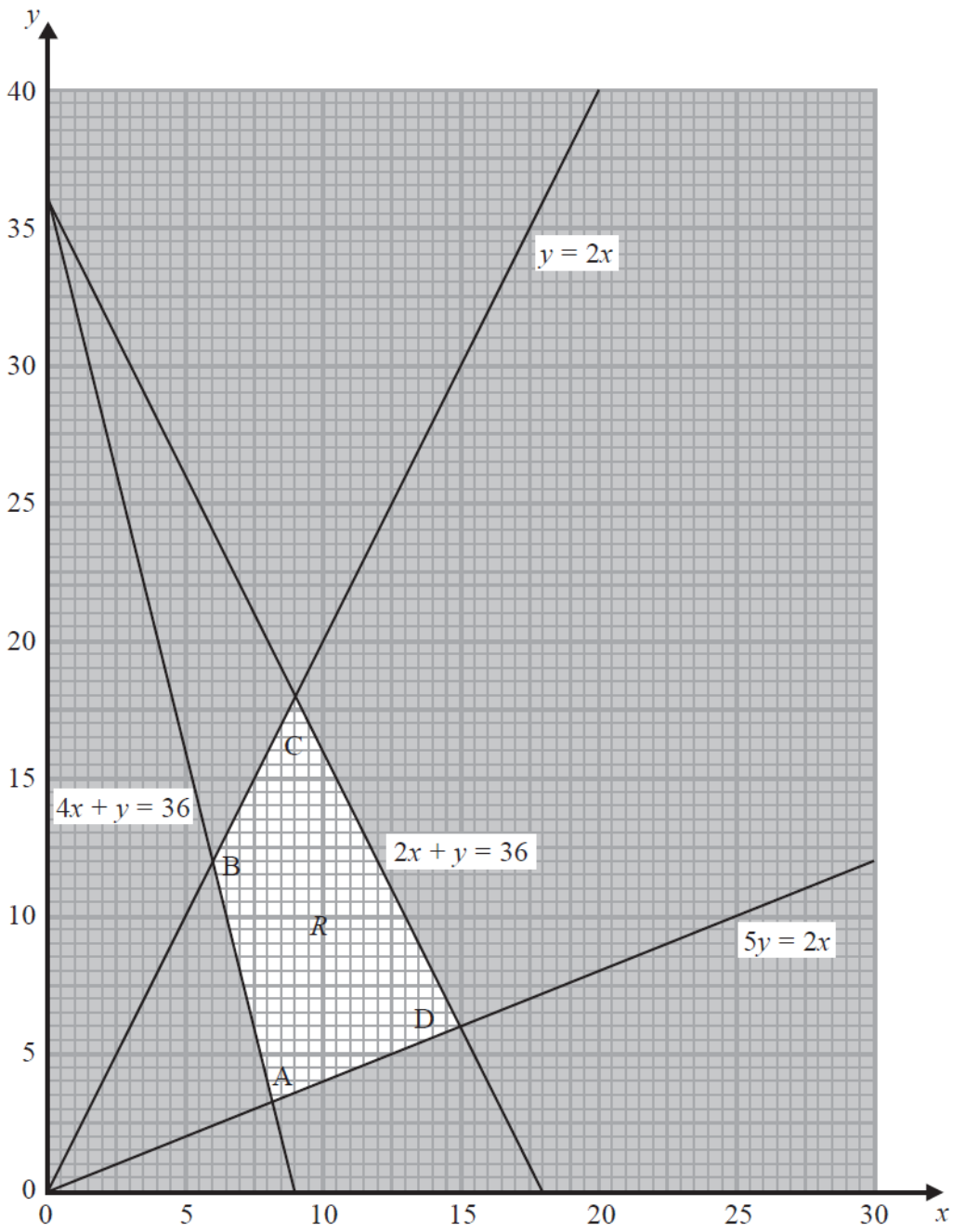
y
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
x
y = 2x
4x + y = 36
2x + y = 36
5y = 2x
A
B
C
D
R

Figure 5

Question 8 continued

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(Total 8 marks)

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Question 9 continued

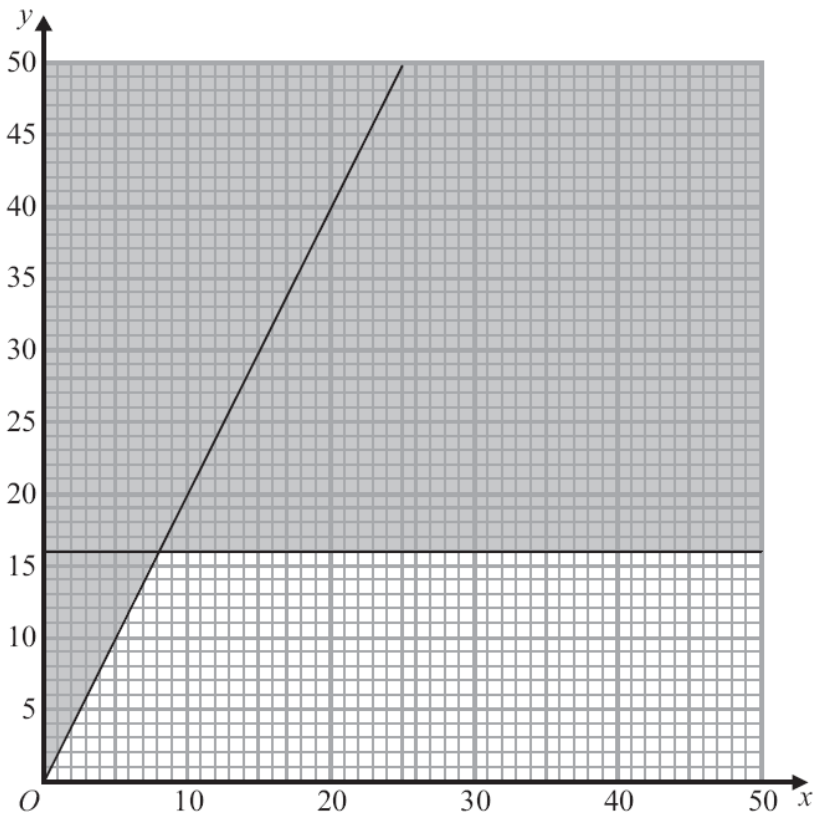

Diagram 1

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(Total 16 marks)

TOTAL FOR PAPER: 100 MARKS

Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Prim and Kruskal

You must have:
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

Instructions

- Use black ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- Fill in the boxes at the top of this page with your name, centre number and candidate number.
- Answer all the 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

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 68.
- The marks for each question are shown in brackets – use this as a guide as to how much time to spend on each question.
- Calculators must not be used for questions marked with a * sign.

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.

1.

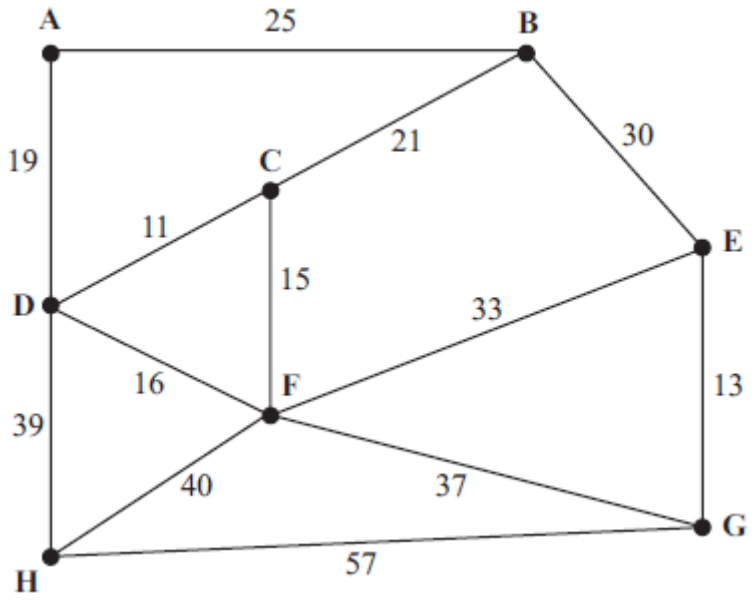

Figure 1

Figure 1 represents the distances, in km, between eight vertices **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H** in a network.

(*a*) Use **Kruskal's** algorithm to find the minimum spanning tree for the network. You should list the arcs in the order in which you consider them. In each case, state whether you are adding the arc to your minimum spanning tree.

(3)

(*b*) Starting at A, use **Prim's** algorithm to find the minimum spanning tree. You must clearly state the order in which you selected the arcs of your tree.

(3)

(*c*) Draw the minimum spanning tree using the vertices given in Diagram 1 in the answer book.

(1)

(*d*) State the weight of the tree.

(1)

(Total 8 marks)

2.

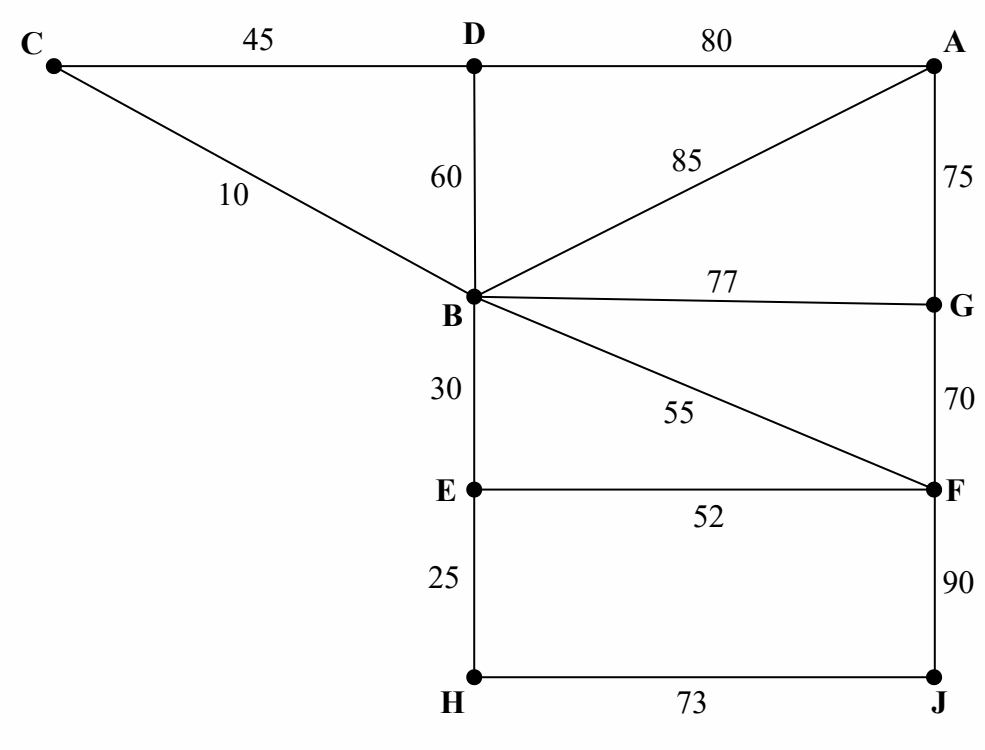

Figure 2

Figure 2 represents nine computer terminals, A, B, C, D, E, F, G, H and J, at Pearsonby School. The school wishes to connect them to form a single computer network. The number on each arc represents the cost, in pounds, of connecting the corresponding computer terminals.

(*a*) Use Prim's algorithm, starting at B, to find the minimum spanning tree for the computer network. You must clearly state the order in which you select the arcs of your tree.

(3)

(*b*) State the minimum cost of connecting the nine computer terminals.

(1)

It is discovered that some computer terminals are already connected. There are already direct connections along BD and FJ, as shown in bold in Diagram 1 in the answer book. It is decided to use these connections.

(*c*) Use Kruskal's algorithm to find the minimum spanning tree that includes arcs BD and FJ. You must list the arcs in the order that you consider them. In each case, state whether or not you are adding the arcs to your spanning tree.

(3)

(Total 7 marks)

3.

	A	B	C	D	E	F
A	–	85	110	160	225	195
B	85	–	100	135	180	150
C	110	100	–	215	200	165
D	160	135	215	–	235	215
E	225	180	200	235	–	140
F	195	150	165	215	140	–

The table shows the average journey time, in minutes, between six towns, A, B, C, D, E and F.

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

(3)

(*b*) Draw your tree using the vertices given in Diagram 1 in the answer book.

(1)

(*c*) Find the weight of your minimum spanning tree.

(1)

Kruskal's algorithm may also be used to find a minimum spanning tree.

(*d*) State three differences between Prim's algorithm and Kruskal's algorithm.

(3)

(Total 8 marks)

4.

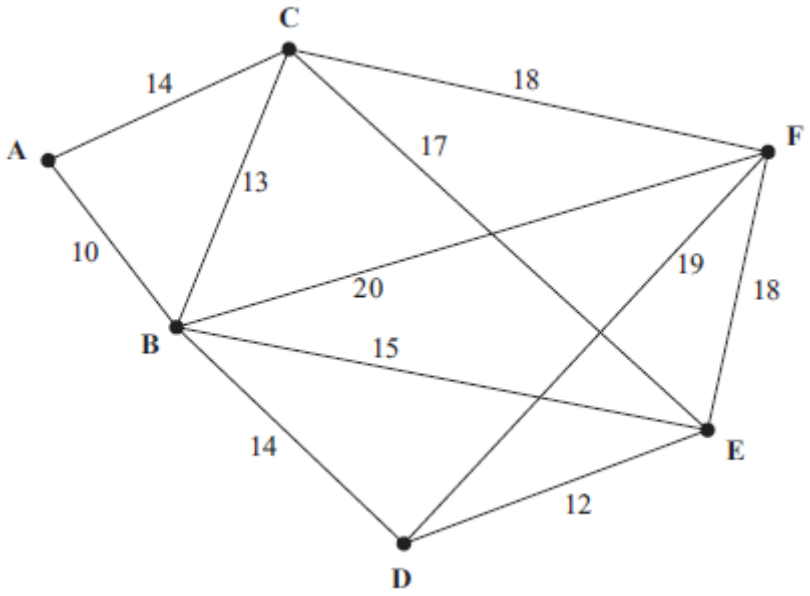

Figure 3

(*a*) Define the terms

(i) tree,

(ii) minimum spanning tree.

(3)

(*b*) Use Kruskal's algorithm to find a minimum spanning tree for the network shown in Figure 3.

You should list the arcs in the order in which you consider them. In each case, state whether you are adding the arc to your minimum spanning tree.

(3)

(*c*) Draw your minimum spanning tree using the vertices given in Diagram 1 in the answer book.

(1)

(*d*) State whether your minimum spanning tree is unique. Justify your answer.

(1)

(Total 8 marks)

5.

	A	B	C	D	E	F
A	–	15	6	9	–	–
B	15	–	12	–	14	–
C	6	12	–	7	10	–
D	9	–	7	–	11	17
E	–	14	10	11	–	5
F	–	–	–	17	5	–

The table shows the times, in days, needed to repair the network of roads between six towns, A, B, C, D, E and F, following a flood.

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

(3)

(*b*) Draw your minimum connector using the vertices given in Diagram 1 in the answer book.

(1)

(*c*) Add arcs from D, E and F to Diagram 2 in the answer book, so that it shows the network of roads shown by the table.

(2)

(*d*) Use **Kruskal's** algorithm to find the minimum connector. You should list the arcs in the order in which you consider them. In each case, state whether you are adding the arc to your minimum connector.

(3)

(*e*) State the minimum time needed, in days, to reconnect the six towns.

(1)

(Total 10 marks)

6.

	A	B	C	D	E	F	G
A	–	15	19	–	22	24	–
B	15	–	–	8	13	–	–
C	19	–	–	12	–	16	–
D	-	8	12	–	10	–	18
E	22	13	–	10	–	15	16
F	24	–	16	–	15	–	17
G	–	–	–	18	16	17	–

The table shows the lengths, in km, of a network of roads between seven villages, A, B, C, D, E, F and G.

(*a*) Complete the drawing of the network in Diagram 1 of the answer book by adding the necessary arcs from vertex D together with their weights.

(2)

(*b*) Use Kruskal's algorithm to find a minimum spanning tree for the network. You should list the arcs in the order that you consider them. In each case, state whether you are adding the arc to your minimum spanning tree.

(3)

(*c*) Draw the minimum spanning tree using the vertices provided in Diagram 2 in the answer book.

(1)

(*d*) State the weight of the minimum spanning tree.

(1)

(Total 7 marks)

7.

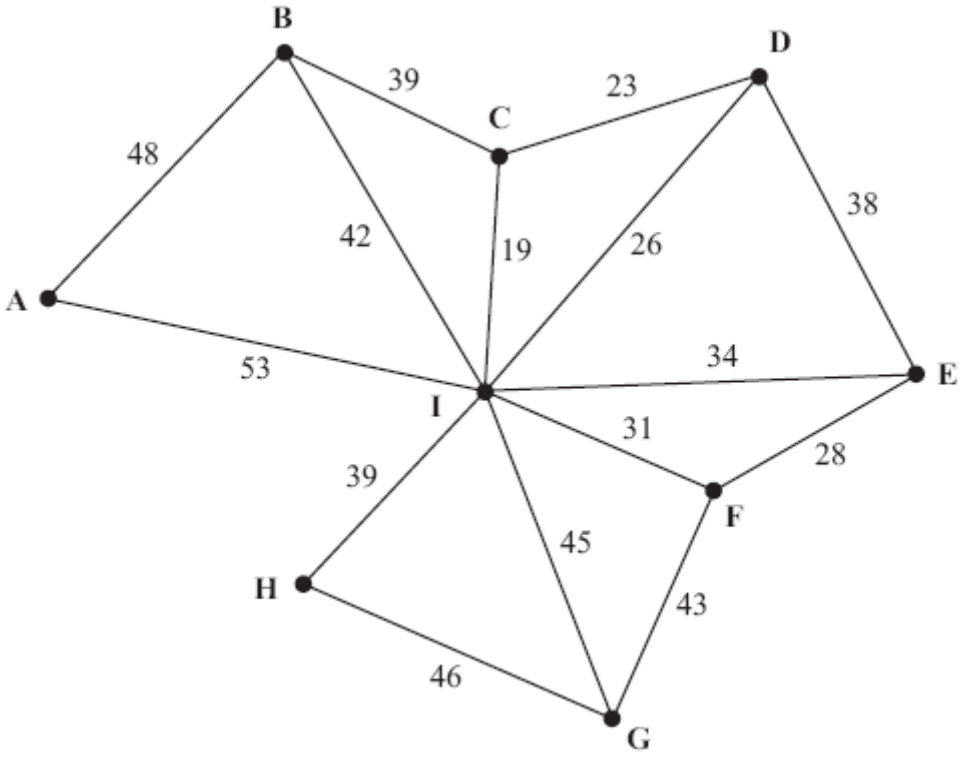

Figure 4

(*a*) Use Kruskal's algorithm to find a minimum spanning tree for the network shown in Figure 4. You should list the arcs in the order in which you consider them. In each case, state whether you are adding the arc to your minimum spanning tree.

(3)

(*b*) Starting at **A**, use Prim's algorithm to find a minimum spanning tree for the network in Figure 4. You must clearly state the order in which you include the arcs in your tree.

(3)

(*c*) Draw a minimum spanning tree for the network in Figure 4 using the vertices given in Diagram 1 of the answer book. State the weight of the minimum spanning tree.

(2)

A new spanning tree is required which includes the arcs **DI** and **HG**, and which has the lowest possible total weight.

(*d*) Explain which algorithm you would choose to complete the tree, and how the algorithm should be adapted. (You do not need to find the tree.)

(2)

(Total 10 marks)

8.

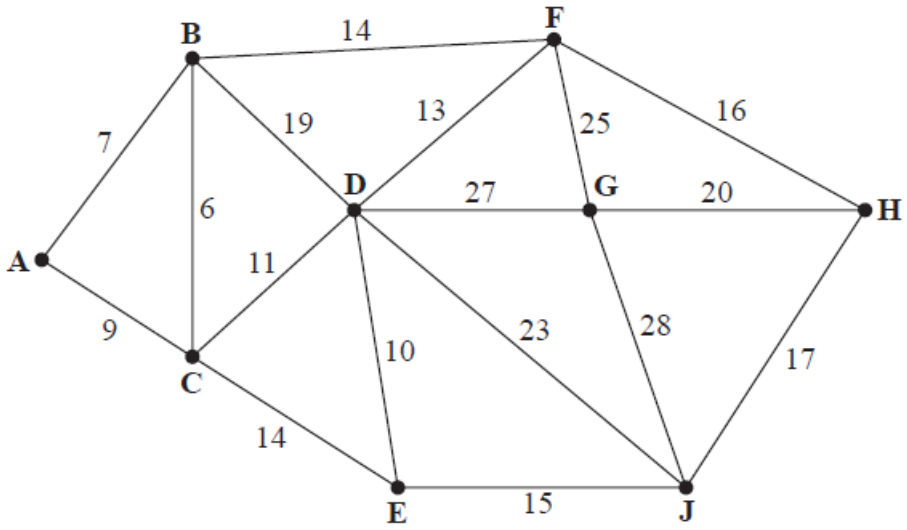

Figure 5

The numbers on the 17 arcs in the network shown in Figure 5 represent the distances, in km, between nine nodes, **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H** and **J**.

(*a*) Use Kruskal's algorithm to find a minimum spanning tree for the network. You should list the arcs in the order in which you consider them. In each case, state whether you are adding the arc to your minimum spanning tree.

(3)

(*b*) Starting at **G**, use Prim's algorithm to find a minimum spanning tree. You must clearly state the order in which you select the arcs of your tree.

(3)

(*c*) Find the weight of the minimum spanning tree.

(1)

A connected graph V has n nodes. The sum of the degrees of all the nodes in V is m. The graph T is a minimum spanning tree of V.

(*d*) (i) Write down, in terms of m, the number of arcs in V.

(ii) Write down, in terms of n, the number of arcs in T.

(iii) Hence, write down an inequality, in terms of m and n, comparing the number of arcs in T and V.

(3)

(Total 10 marks)

TOTAL FOR PAPER: 68 MARKS

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Prim and Kruskal

Answer Book
Do not return the question paper with the answer book.

Total Marks

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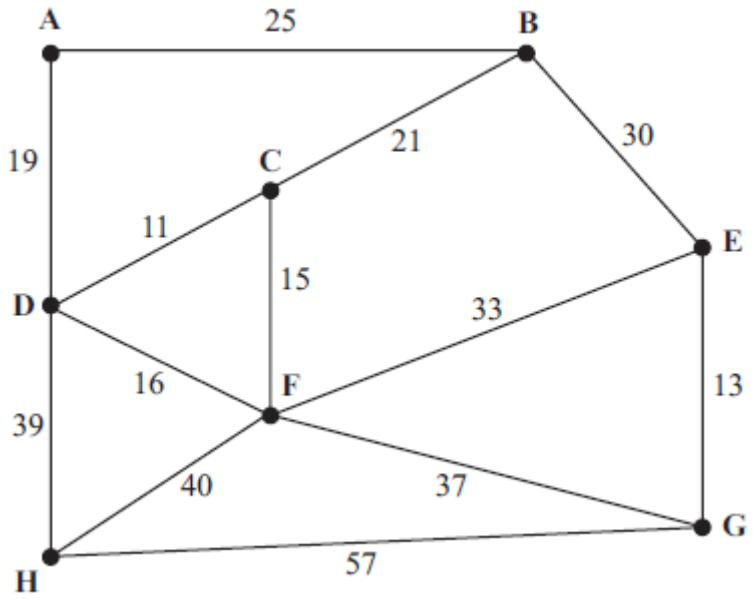

Figure 1

Question 1 continued

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(c)

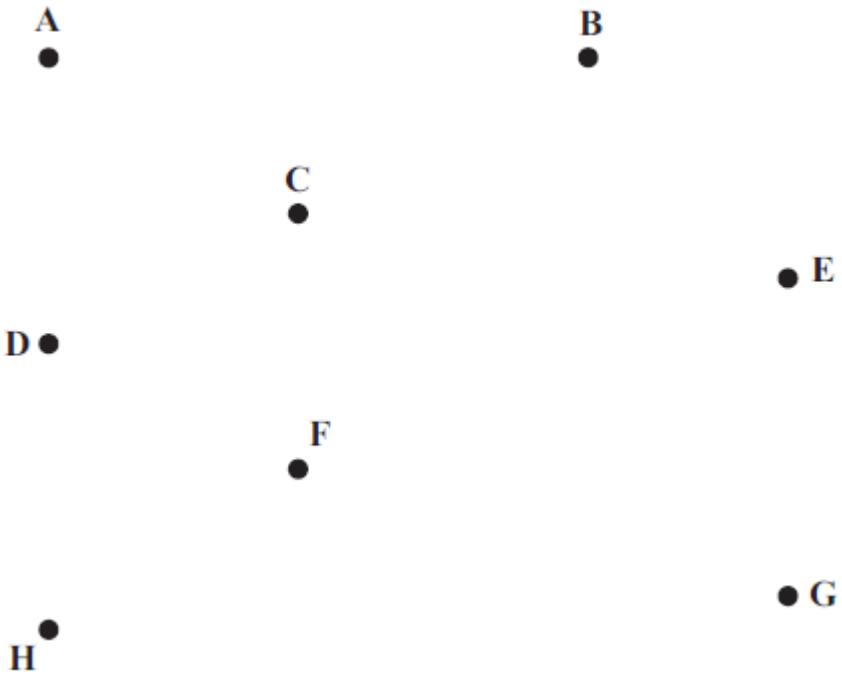

Diagram 1

Weight of tree _____

(Total 8 marks)

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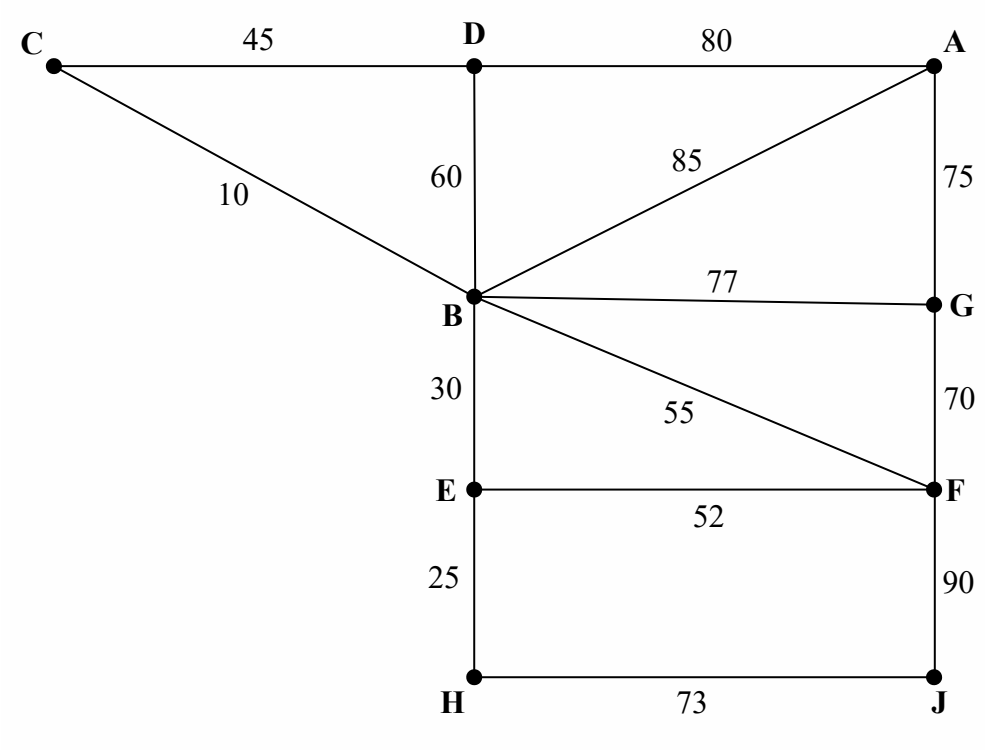

Figure 2

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Question 2 continued

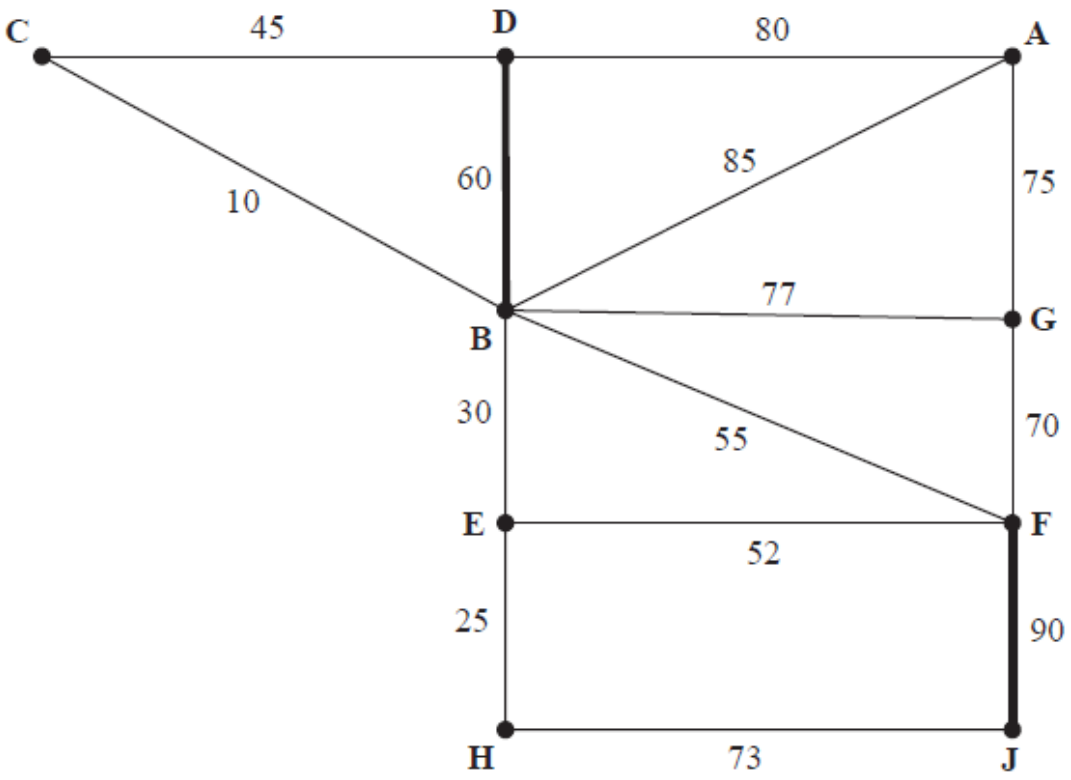

Diagram 1

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(Total 7 marks)

3.

	A	B	C	D	E	F
A	–	85	110	160	225	195
B	85	–	100	135	180	150
C	110	100	–	215	200	165
D	160	135	215	–	235	215
E	225	180	200	235	–	140
F	195	150	165	215	140	–

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Question 3 continued

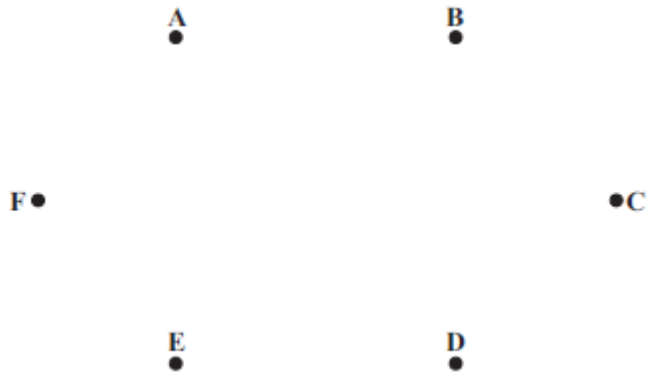

Diagram 1

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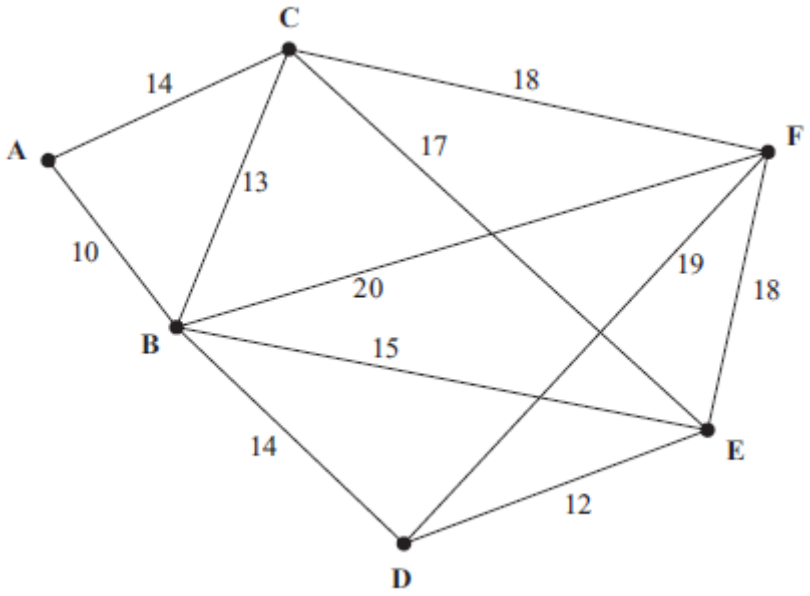

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(c)

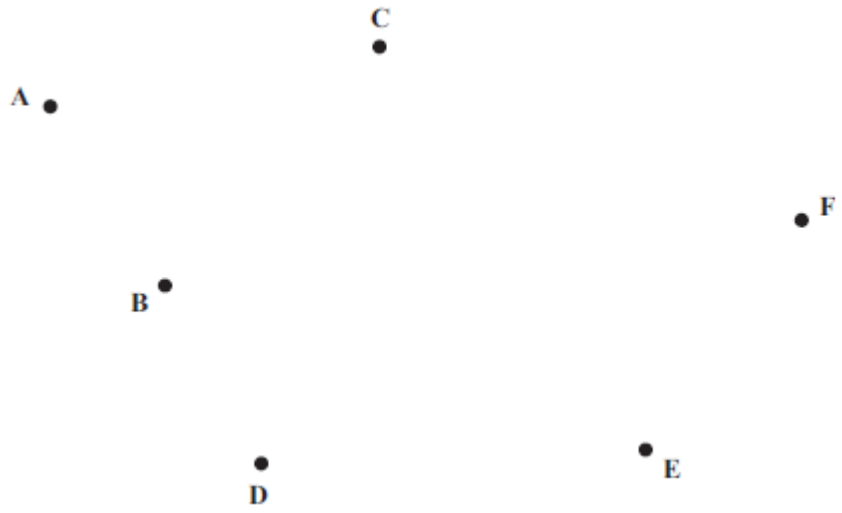

Diagram 1

(d)

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(Total 8 marks)

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5. (a)

	A	B	C	D	E	F
A	–	15	6	9	–	–
B	15	–	12	–	14	–
C	6	12	–	7	10	–
D	9	–	7	–	11	17
E	–	14	10	11	–	5
F	–	–	–	17	5	–

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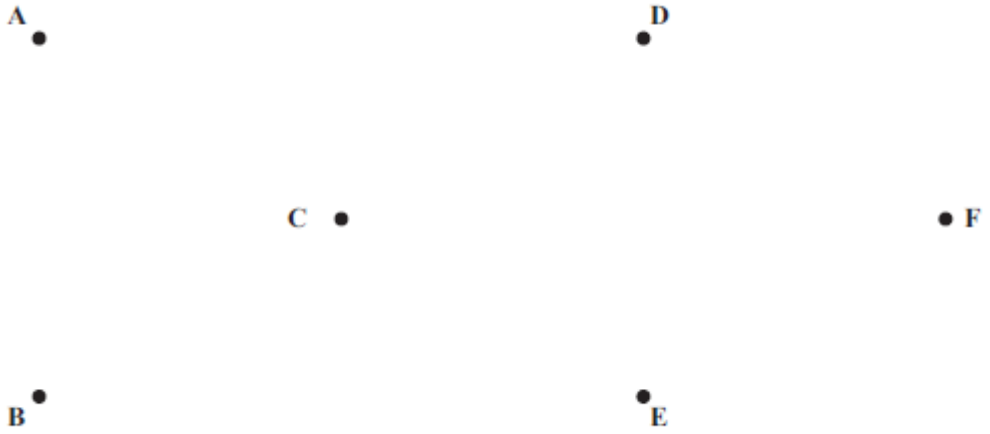
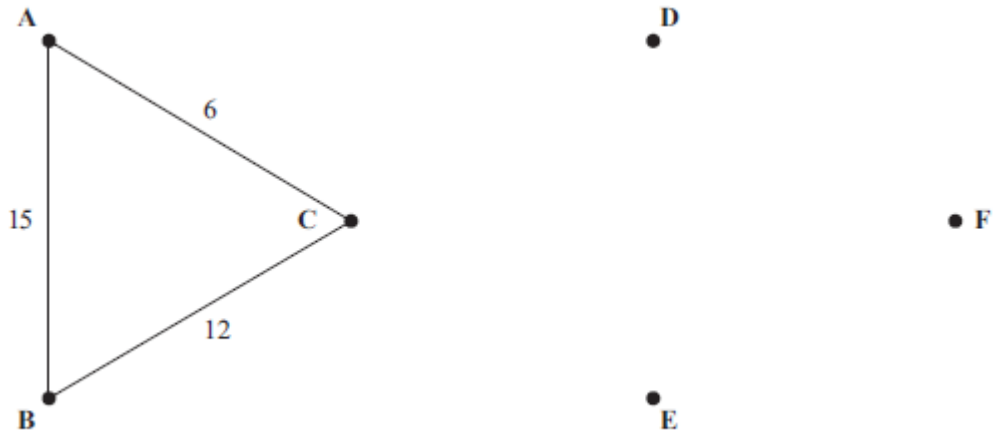
Order of arcs ……..……..

(b)



Question 5 continued

(c)



(d)

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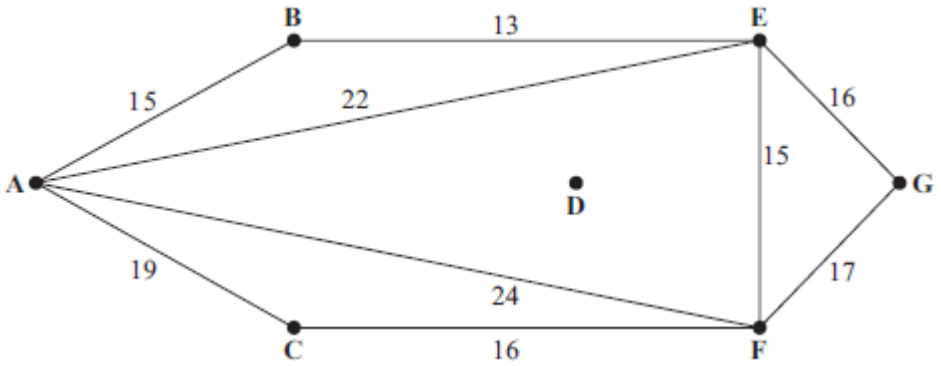
(e) Minimum time needed ……..

(Total 10 marks)

6.

	A	B	C	D	E	F	G
A	–	15	19	–	22	24	–
B	15	–	–	8	13	–	–
C	19	–	–	12	–	16	–
D	-	8	12	–	10	–	18
E	22	13	–	10	–	15	16
F	24	–	16	–	15	–	17
G	–	–	–	18	16	17	–

(a)



(b)

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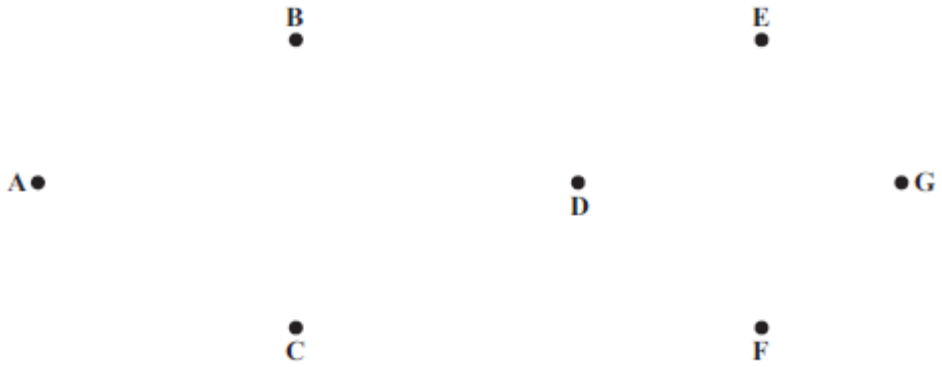
(c)



(d) Weight of minimum spanning tree …….

(Total 7 marks)

7.

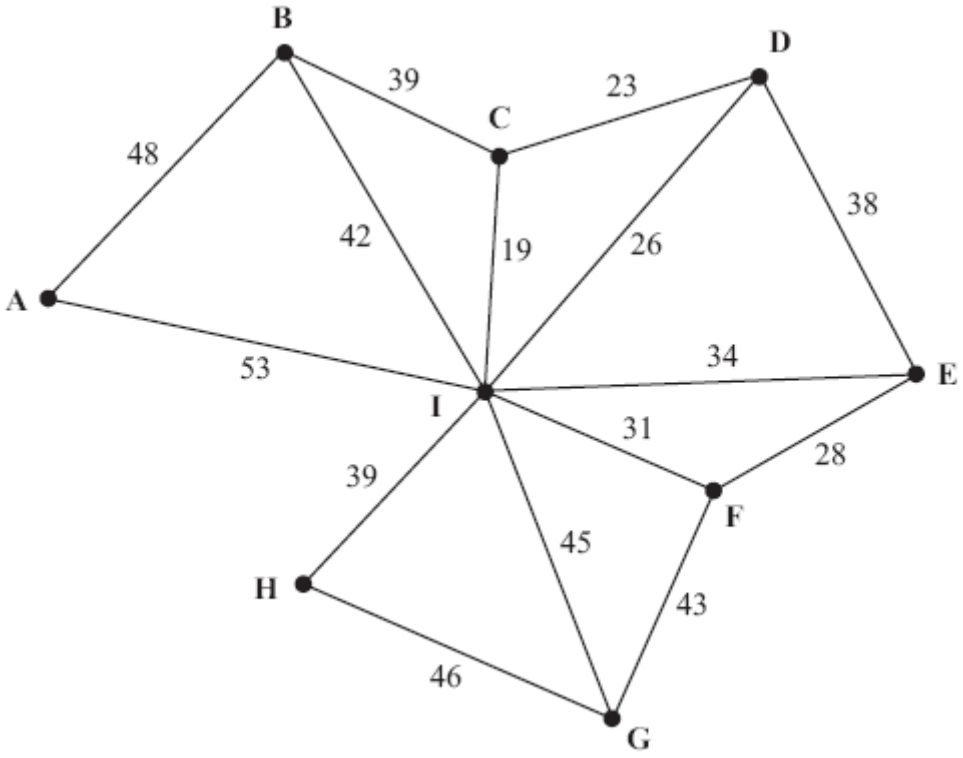


Figure 4

(a)

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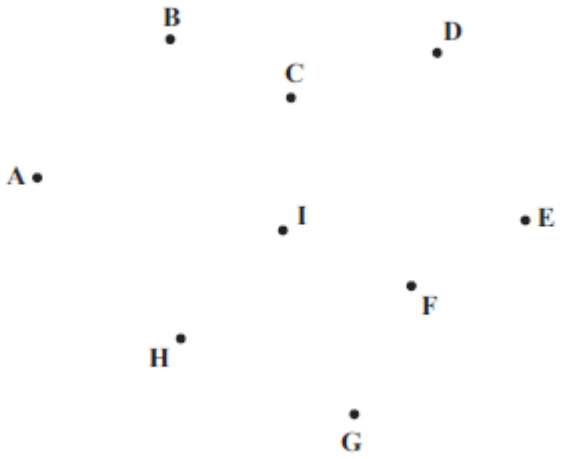

Weight of minimum spanning tree ……..

(d)

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(Total 10 marks)

8.

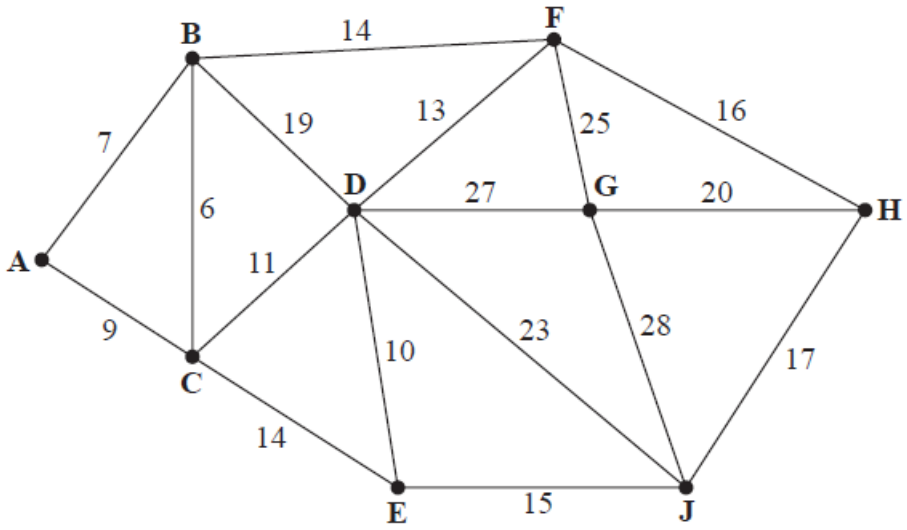

Figure 5

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Question 7 continued

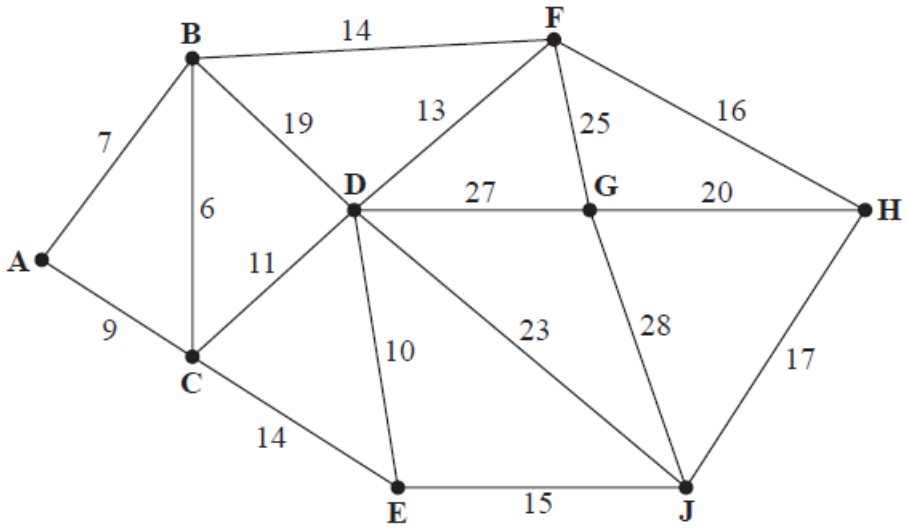

Figure 5

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(Total 10 marks)

TOTAL FOR PAPER: 68 MARKS

Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Route inspection problems

You must have:
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

Instructions

- Use black ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- Fill in the boxes at the top of this page with your name, centre number and candidate number.
- Answer all the 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

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 100.
- The marks for each question are shown in brackets – use this as a guide as to how much time to spend on each question.
- Calculators must not be used for questions marked with a * sign.

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.

1.

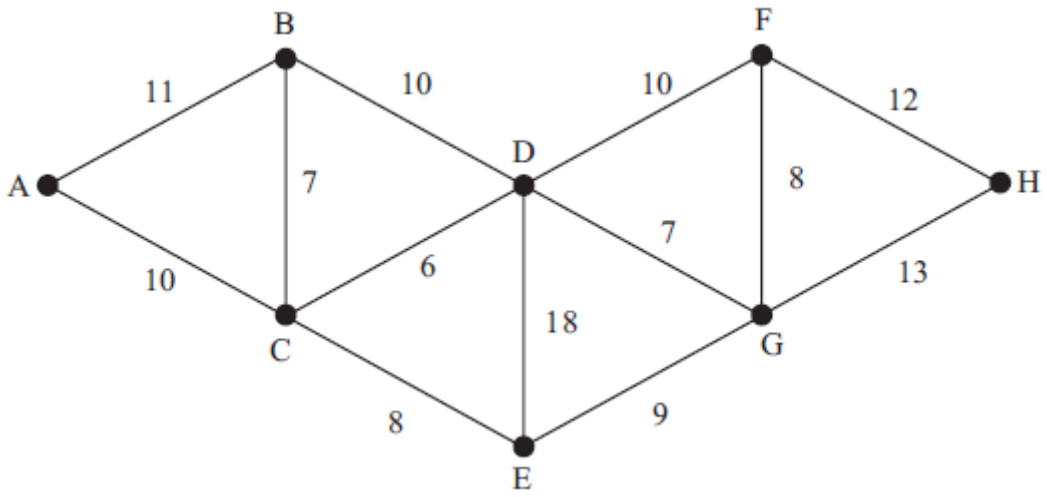

Figure 1

[*The weight of the network is 129 miles*.]

Figure 1 models a network of canals. The number on each arc gives the length, in miles, of that canal.

Brett needs to travel along each canal to check that it is in good repair. He wishes to minimise the length of his route.

(*a*) Use the route inspection algorithm to find the length of his route. State the arcs that should be repeated. You should make your method and working clear.

(6)

A canal between B and F, of length 12 miles, is to be opened and needs to be included in Brett's inspection route.

(*b*) Determine if the addition of this canal will increase or decrease the length of Brett's minimum route. You must make your reasoning clear.

(2)

(Total 8 marks)

2.

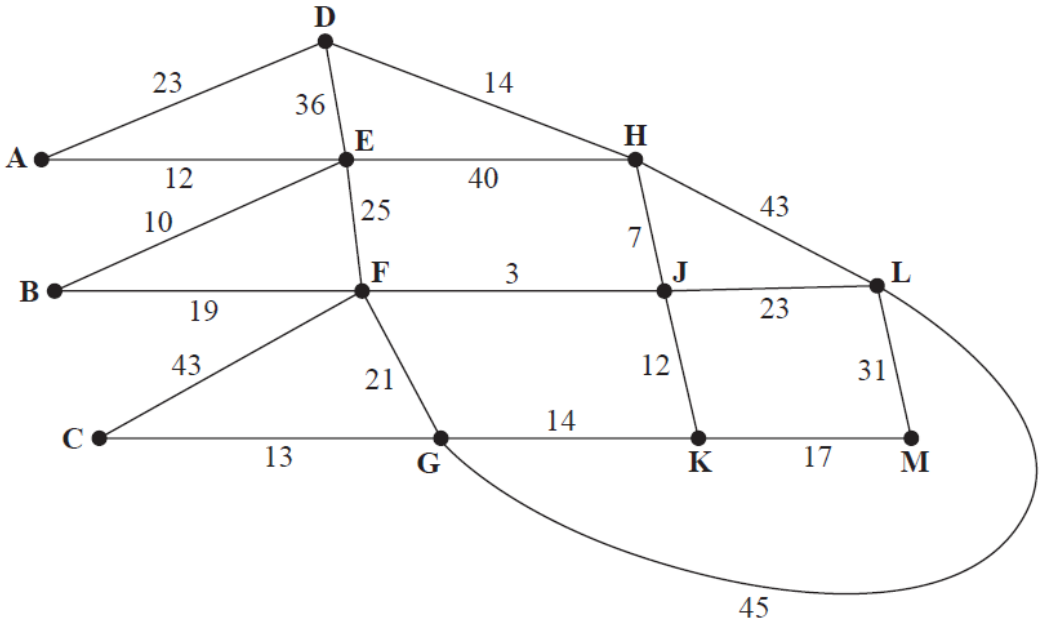

Figure 2

[The total weight of the network is 451]

Figure 2 models a network of tracks in a forest that need to be inspected by a park ranger. The number on each arc is the length, in km, of that section of the forest track.

Each track must be traversed at least once and the length of the inspection route must be minimised. The inspection route taken by the ranger must start and end at vertex A.

(*a*) Use the route inspection algorithm to find the length of a shortest inspection route. State the arcs that should be repeated. You should make your method and working clear.

(5)

(*b*) State the number of times that vertex J would appear in the inspection route.

(1)

The landowner decides to build two huts, one hut at vertex K and the other hut at a different vertex. In future, the ranger will be able to start his inspection route at one hut and finish at the other. The inspection route must still traverse each track at least once.

(*c*) Determine where the other hut should be built so that the length of the route is minimised. You must give reasons for your answer and state a possible route and its length.

(4)

(Total 10 marks)

3.

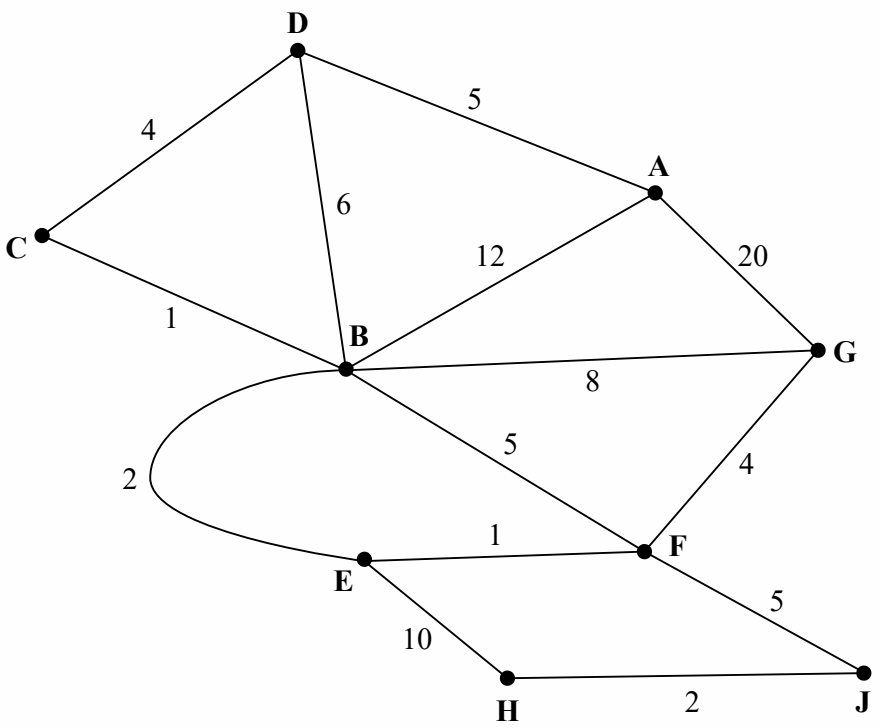

Figure 3

[*The total weight of the network is 85*]

Figure 3 represents a network of roads. The number on each edge represents the length, in miles, of the corresponding road. Robyn wishes to travel from A to H. She wishes to minimise the distance she travels.

(*a*) Use Dijkstra's algorithm to find the shortest path from A to H. State the shortest path and its length.

(6)

On a particular day, Robyn needs to check each road. She must travel along each road at least once. Robyn must start and finish at vertex A.

(*b*) Use the route inspection algorithm to find the length of the shortest inspection route. State the edges that should be repeated. You should make your method and working clear.

(5)

The roads BD and BE become damaged and cannot be used. Robyn needs to travel along all the remaining roads to check that there is no damage to any of them. The inspection route must still start and finish at vertex A.

(*c*) (i) State the edges that should be repeated.

(ii) State a possible route and calculate its length. You must make your method and working clear.

(4)

(Total 15 marks)

4.

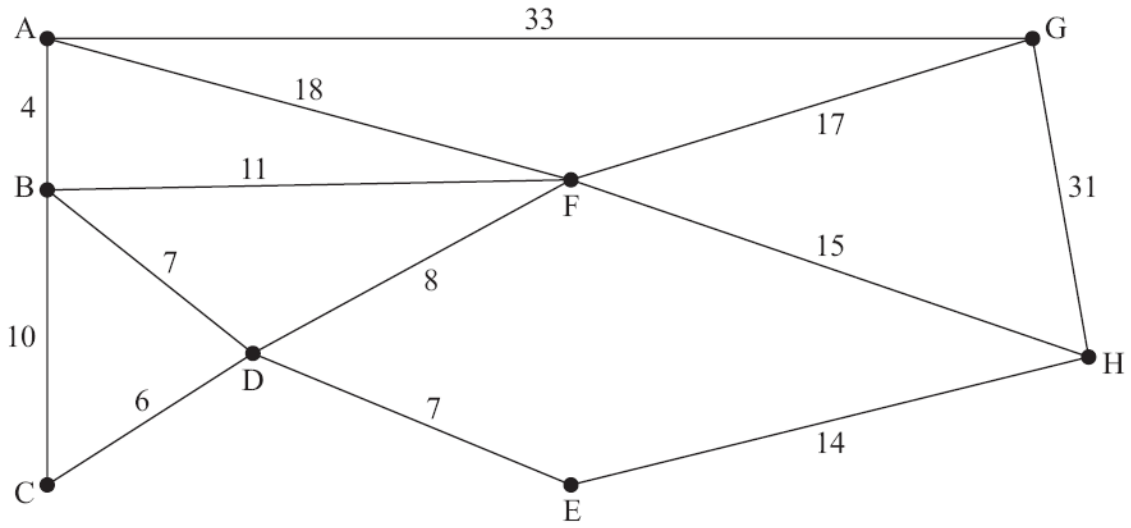

Figure 4

[*The total weight of the network is 181 miles*]

Figure 4 represents a network of power cables that have to be inspected. The number on each arc represents the length, in km, of that cable.

A route of minimum length that traverses each cable at least once and starts and finishes at A needs to be found.

(*a*) Use the route inspection algorithm to find the arcs that will need to be traversed twice. You must make your method and working clear.

(5)

(*b*) Write down a possible shortest inspection route, giving its length.

(2)

It is now decided to start and finish the inspection route at two distinct vertices. The route must still traverse each cable at least once.

(*c*) Determine possible starting and finishing points so that the length of the route is minimised. You must give reasons for your answer.

(3)

(Total 10 marks)

5.

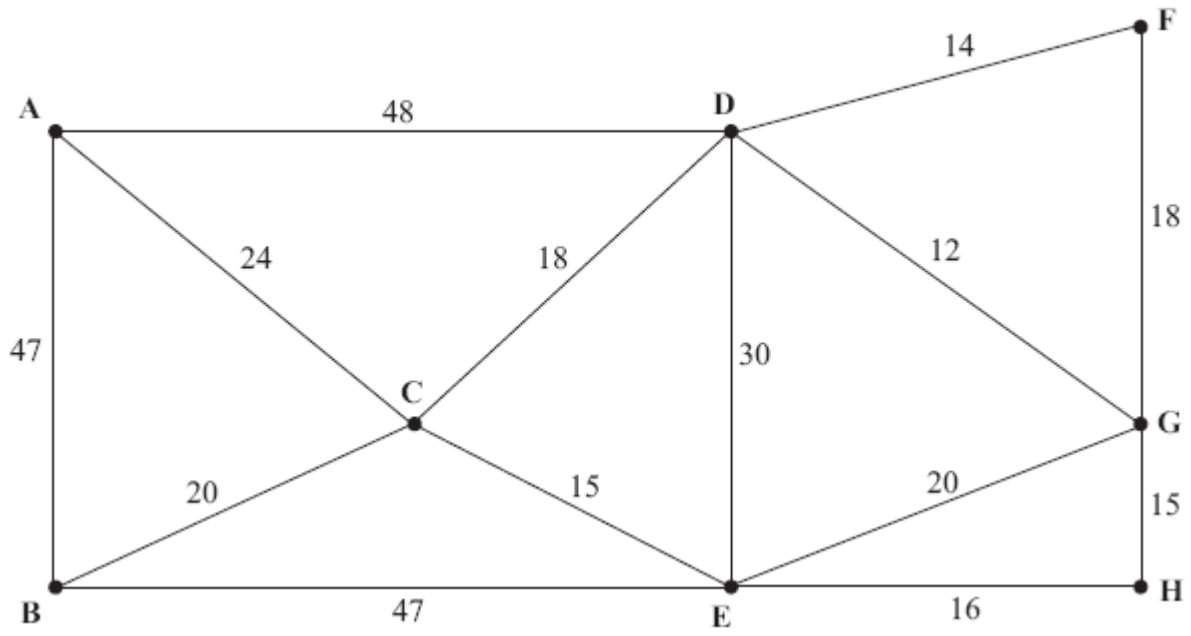

Figure 5

[*The total weight of the network is 344 miles*]

Figure 5 represents a railway network. The number on each arc represents the length, in miles, of that section of the railway.

Sophie needs to travel along each section to check that it is in good condition.

She must travel along each arc of the network at least once, and wants to find a route of minimum length. She will start and finish at **A**.

(*a*) Use the route inspection algorithm to find the arcs that will need to be traversed twice. You must make your method and working clear.

(5)

(*b*) Write down a possible shortest inspection route, giving its length.

(2)

Sophie now decides to start the inspection route at **E**. The route must still traverse each arc at least once but may finish at any vertex.

(*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 your route.

(3)

(Total 10 marks)

6.

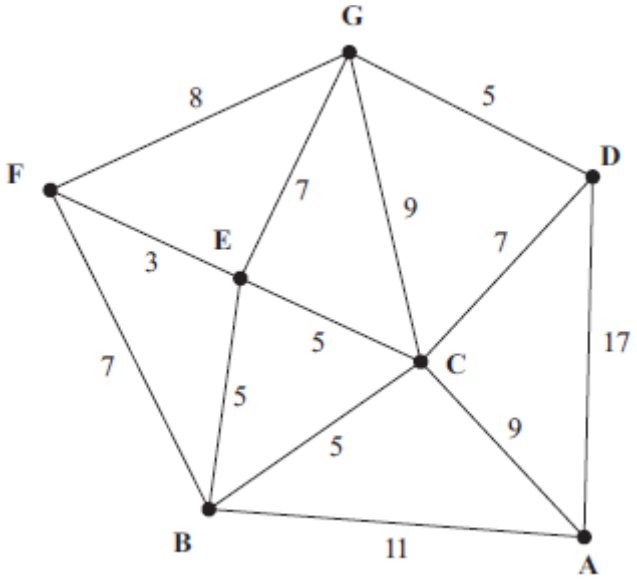

Figure 6

[*The total weight of the network is 98 km.*]

Figure 6 models a network of gas pipes that have to be inspected. The number on each arc represents the length, in km, of that pipe.

A route of minimum length that traverses each pipe at least once and starts and finishes at **A** needs to be found.

(*a*) Use the route inspection algorithm to find the pipes that will need to be traversed twice. You must make your method and working clear.

(5)

(*b*) Write down a possible shortest inspection route, giving its length.

(2)

It is now decided to start the inspection route at **D**. The route must still traverse each pipe at least once but may finish at any node.

(*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 your route.

(3)

(Total 10 marks)

7.

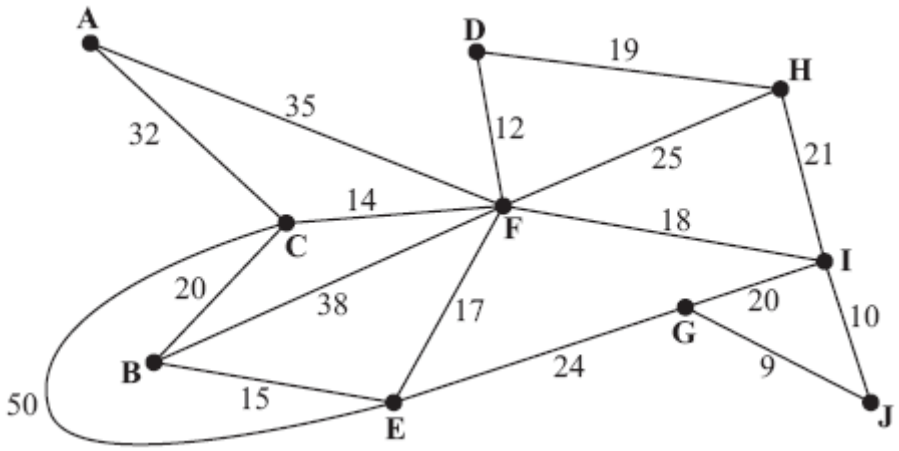

Figure 7

[The weight of the network is 379]

Figure 7 represents the roads in a highland wildlife conservation park. The vertices represent warden stations. The number on each arc gives the length, in km, of the corresponding road.

During the winter months the park is closed. It is only necessary to ensure road access to the warden stations.

(*a*) Use Prim's algorithm, starting at **A**, to find a minimum connector for the network in Figure 5. You must state the **order** in which you include the **arcs**.

(3)

(*b*) Given that it costs £80 per km to keep the selected roads open in winter, calculate the minimum cost of ensuring road access to all the warden stations.

(2)

At the end of winter, Ben inspects all the roads before the park re-opens. He needs to travel along each road at least once. He will start and finish at **A**, and wishes to minimise the length of his route.

(*c*) Use the route inspection algorithm to find the roads that will be traversed twice. You must make your method and working clear.

(6)

(*d*) Find the length of the shortest inspection route.

(1)

If Ben starts and finishes his inspection route at different warden stations, a shorter inspection route is possible.

(*e*) Determine the two warden stations Ben should choose as his starting and finishing points in order that his route has minimum length. Give a reason for your answer and state the length of the route.

(3)

(Total 15 marks)

8.

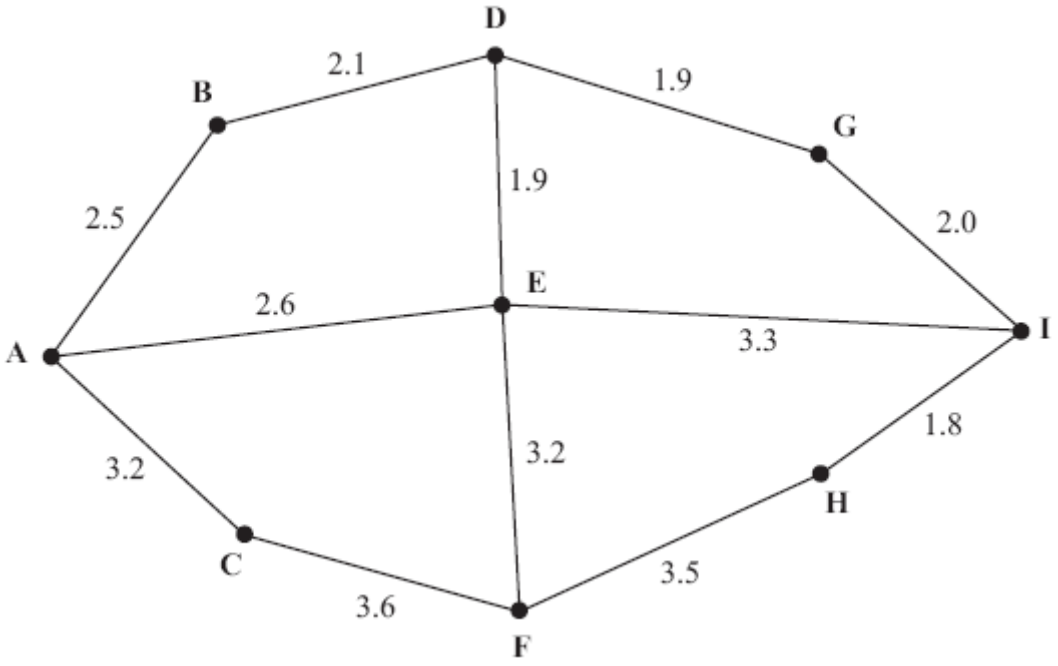

Figure 8

[*The total weight of the network is* 31.6 *km*]

Figure 8 models a network of roads. The road markings on these roads are to be renewed. The number on each arc represents the length, in km, of that road. In order to renew the road markings, each road must be traversed at least once.

(*a*) Use the route inspection algorithm, starting and finishing at **A**, to find a suitable route, which should be stated. You must make your method and working clear.

(5)

(*b*) State the roads that must be traversed twice and the length of the route.

(3)

The machine that will be used to renew the road markings can only be delivered to **D**. It will start at **D**, but it may finish at any vertex.

Each road must still be traversed at least once.

(*c*) Given that the route is to be minimised, determine where the machine should finish. Give reasons to justify your answer.

(3)

(Total 11 marks)

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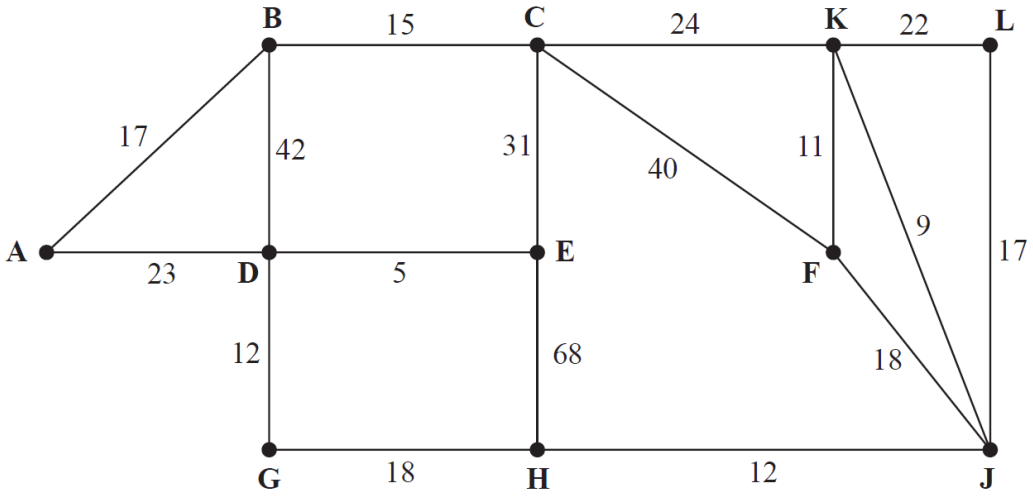

Figure 9

[*The total weight of the network is 384*]

Figure 9 models a network of corridors in an office complex that need to be inspected by a security guard. The number on each arc is the length, in metres, of the corresponding section of corridor.

Each corridor must be traversed at least once and the length of the inspection route must be minimised. The guard must start and finish at vertex **A**.

(*a*) Use the route inspection algorithm to find the length of the shortest inspection route. State the arcs that should be repeated. You should make your method and working clear.

(5)

It is now possible for the guard to start at one vertex and finish at a different vertex. An inspection route that traverses each corridor at least once is still required.

(*b*) Explain why the inspection route should start at a vertex with odd degree.

(2)

The guard decides to start the inspection route at **F** and the length of the inspection route must still be minimised.

(*c*) Determine where the guard should finish. You must give reasons for your answer.

(2)

(*d*) State a possible route and its length.

(2)

(Total 11 marks)

TOTAL FOR PAPER: 100 MARKS

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

AS and A level Further Mathematics
Decision Mathematics 1

Practice Paper
Route inspection problems

Answer Book
Do not return the question paper with the answer book.

Total Marks

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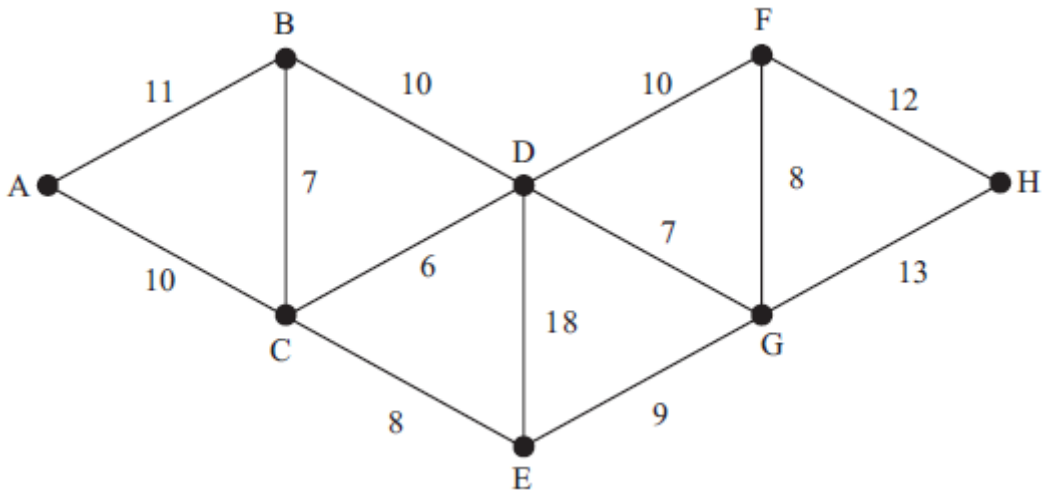

Figure 1

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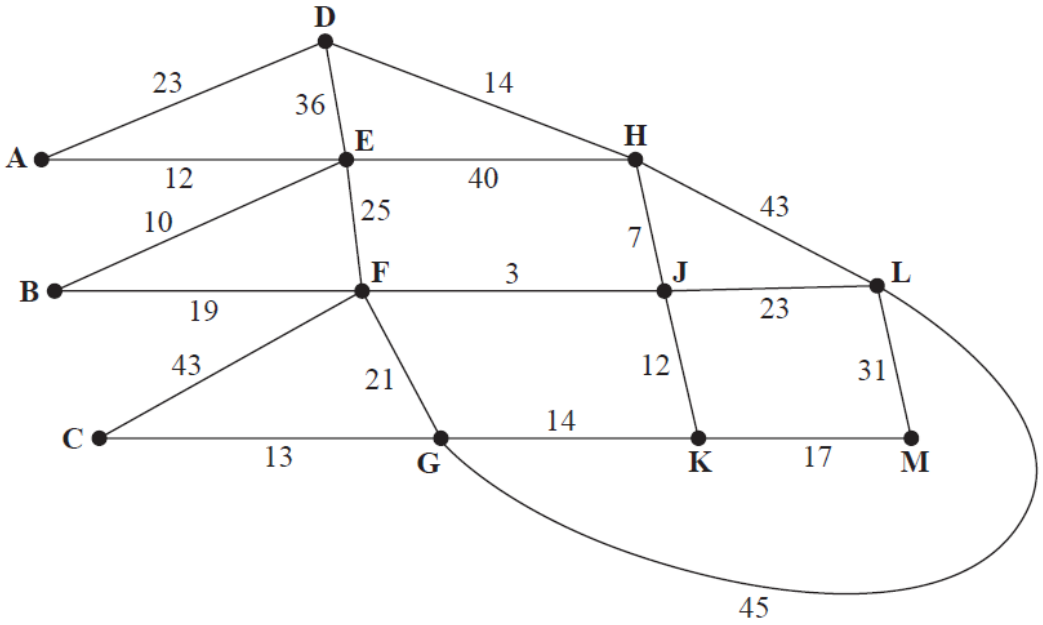
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Figure 2

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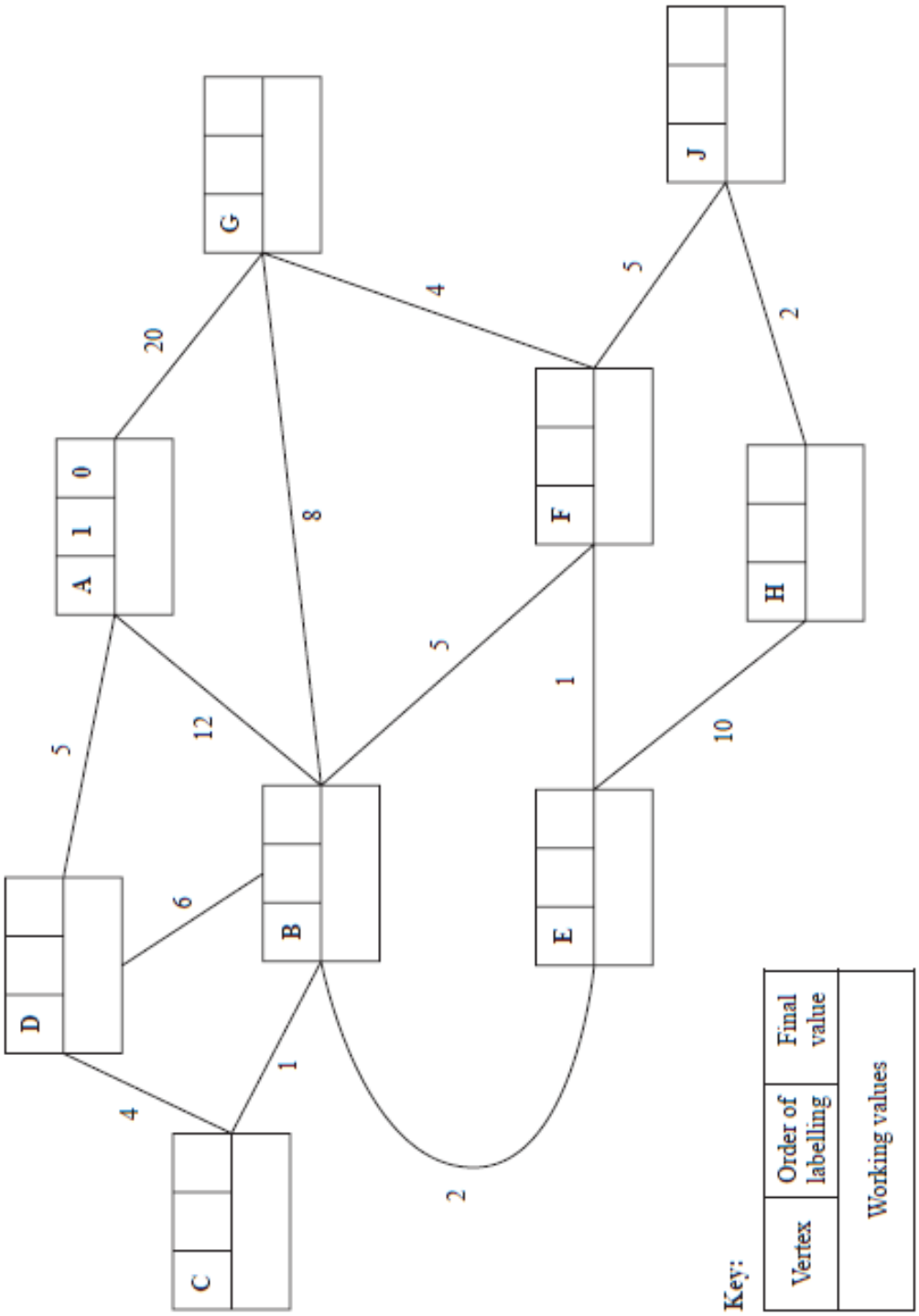

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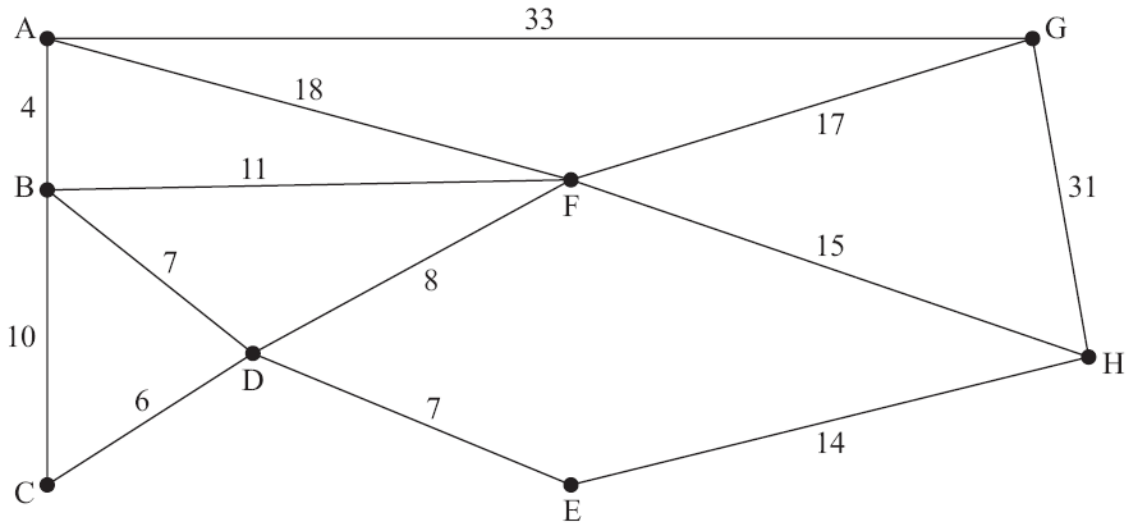

Figure 4

[*The total weight of the network is 181 miles*]

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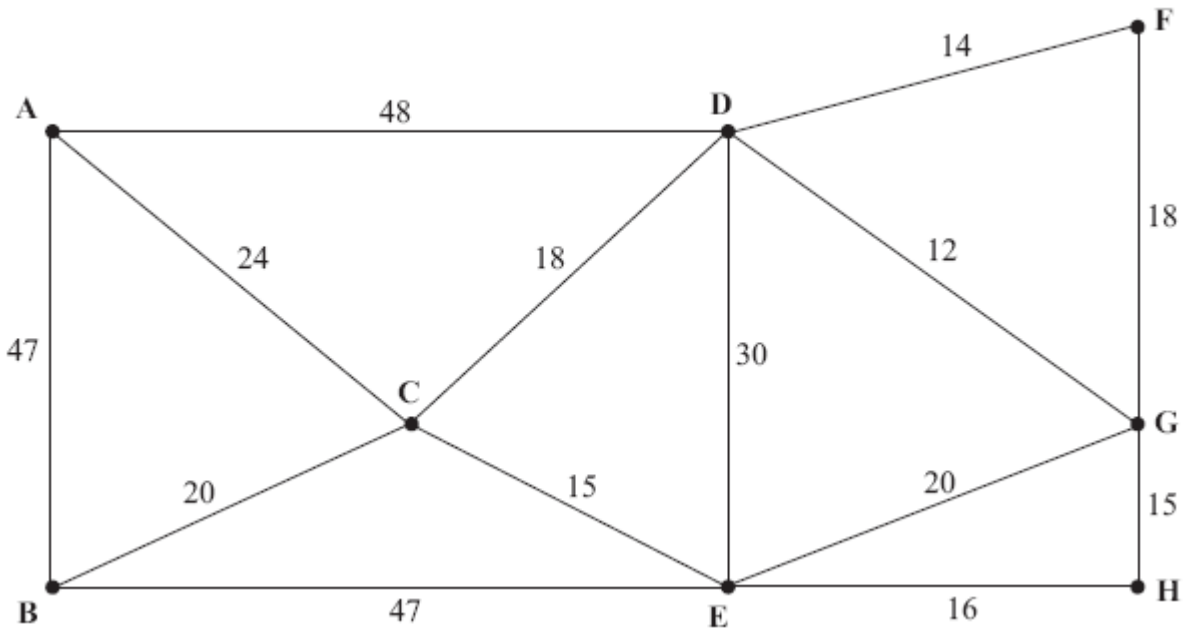

Figure 5

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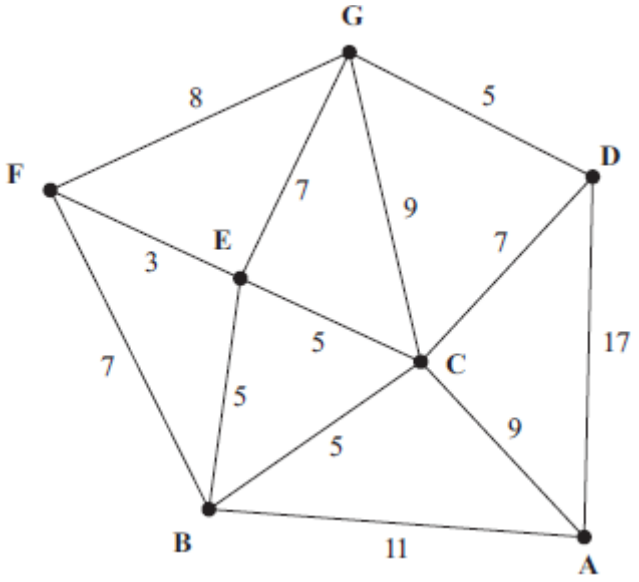

Figure 6

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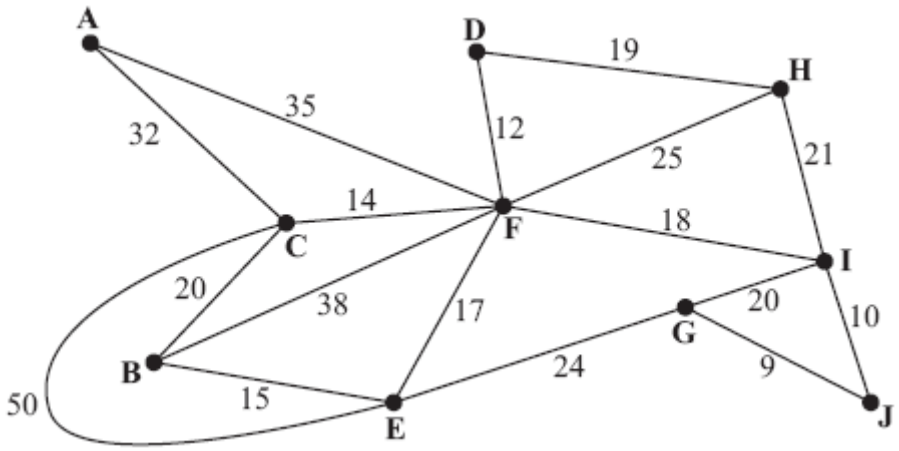

Figure 7

Question 7 continued

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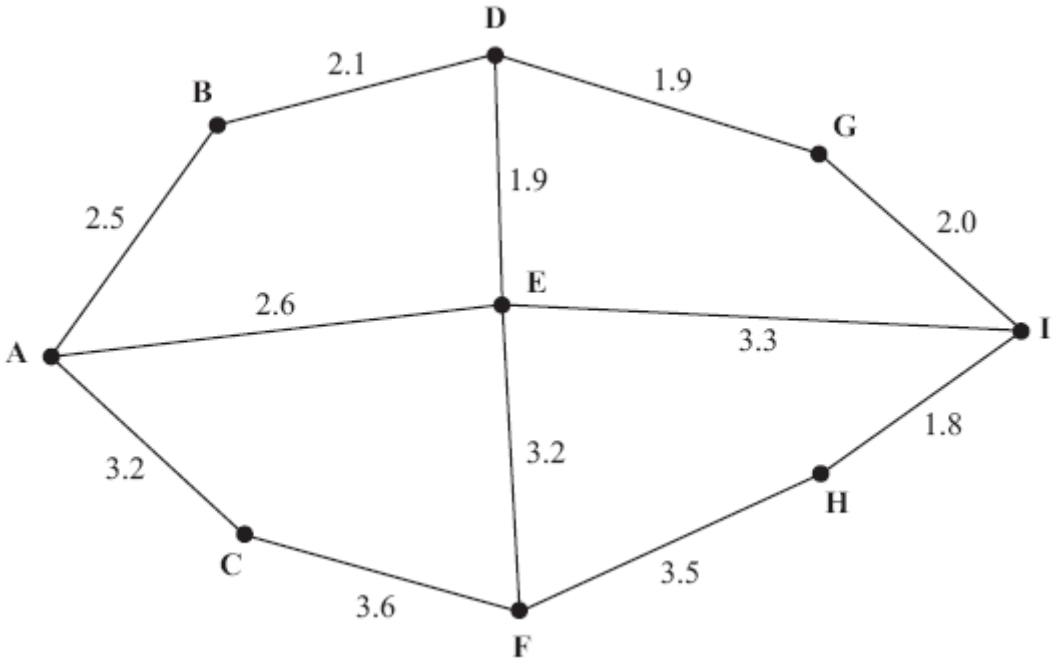

Figure 8

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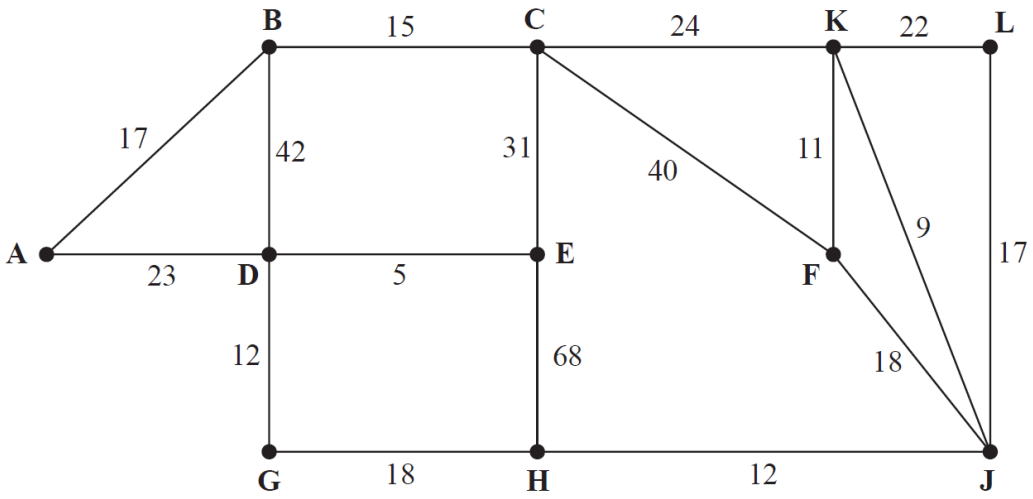

Figure 9

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