Pearson Edexcel International Advanced Level

Thursday 16 May 2024

Afternoon (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 allowed 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). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** on the top of the answer book with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the D1 answer book 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.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.
- Do not return the question paper with the answer book.

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.

Turn over ▶

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

1.

5.2	4.7	6.5	4.5	3.1	5.1	1.8	2.9	3.4	3.8	1.2

(a) Use the first-fit bin packing algorithm to determine how the eleven numbers listed above can be packed into bins of size 14

(3)

(b) The list of numbers is to be sorted into **ascending** 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) Apply the first-fit decreasing bin packing algorithm to the sorted list to pack the numbers into bins of size 14

(3)

(d) Explain why the number of bins used in part (c) is optimal.

(1)

(e) Use the binary search algorithm to **try** to locate 3.0 in the list of numbers. Clearly indicate how you choose your pivots and which part of the list is rejected at each stage.

(3)

(Total for Question 1 is 14 marks)

2.

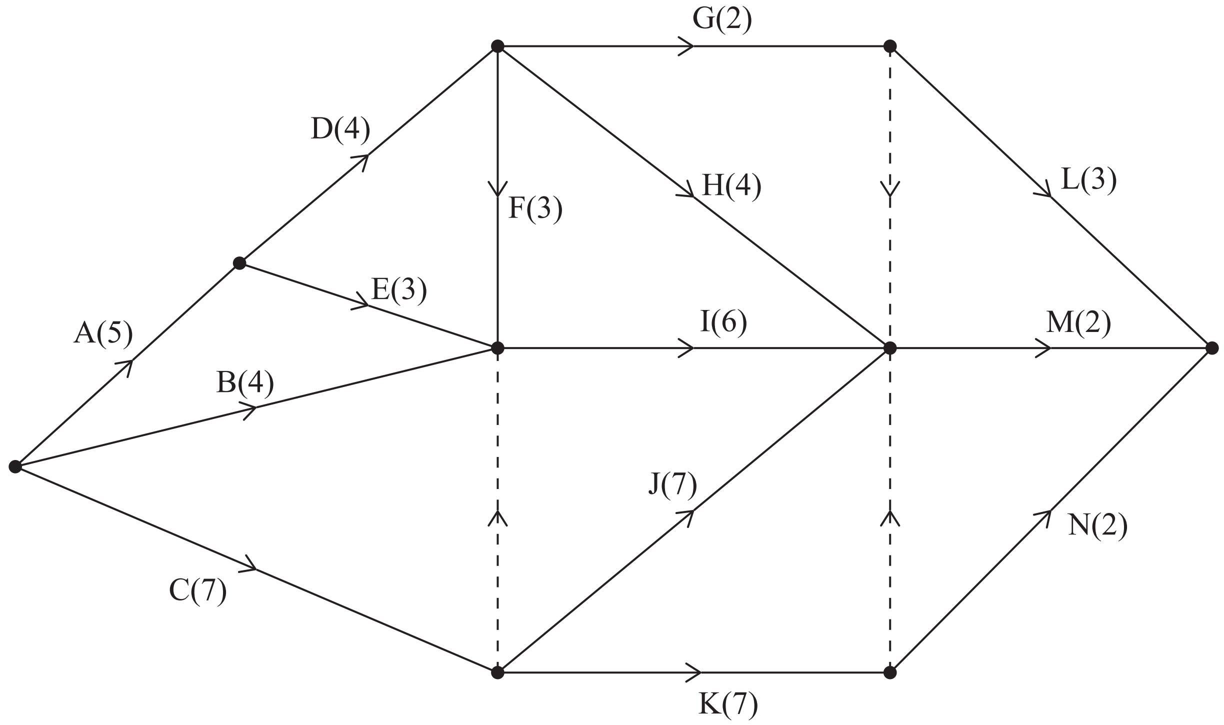

Figure 1

[*The sum of the durations of all the activities is* 59 *days*.]

The network in Figure 1 shows the activities that need to be undertaken to complete a project. Each activity is represented by an arc and the duration, in days, of the corresponding activity is shown in brackets. Each activity requires one worker. The project is to be completed in the shortest possible time.

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

(ii) State the minimum completion time of the project.

(5)

(b) Calculate a lower bound for the number of workers needed to complete the project in the minimum time. You must show your working.

(1)

(c) Schedule the activities using the minimum number of workers so that the project is completed in the minimum time.

(4)

(Total for Question 2 is 10 marks)

3.

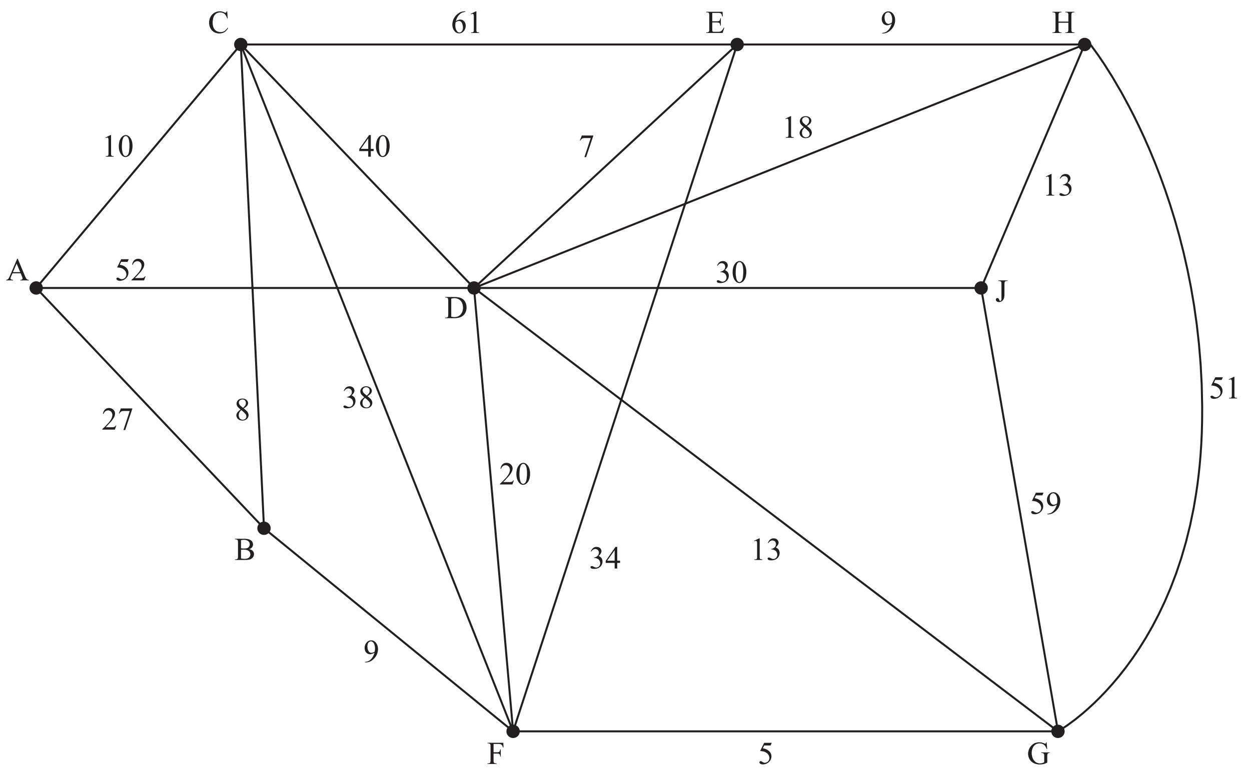

Figure 2

Figure 2 models a network of tracks between nine ranger stations, A, B, C, D, E, F, G, H and J, in a forest. The number on each edge gives the time, in minutes, to travel along the corresponding track. The forest ranger wishes to travel from A to J as quickly as possible.

(a) Use Dijkstra's algorithm to find the shortest time needed to travel from A to J.

State the quickest route.

(6)

(b) Hence determine the weight of the minimum spanning tree for the network given in Figure 2. Give a reason for your answer.

You do not need to find the minimum spanning tree.

(2)

(Total for Question 3 is 8 marks)

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4.

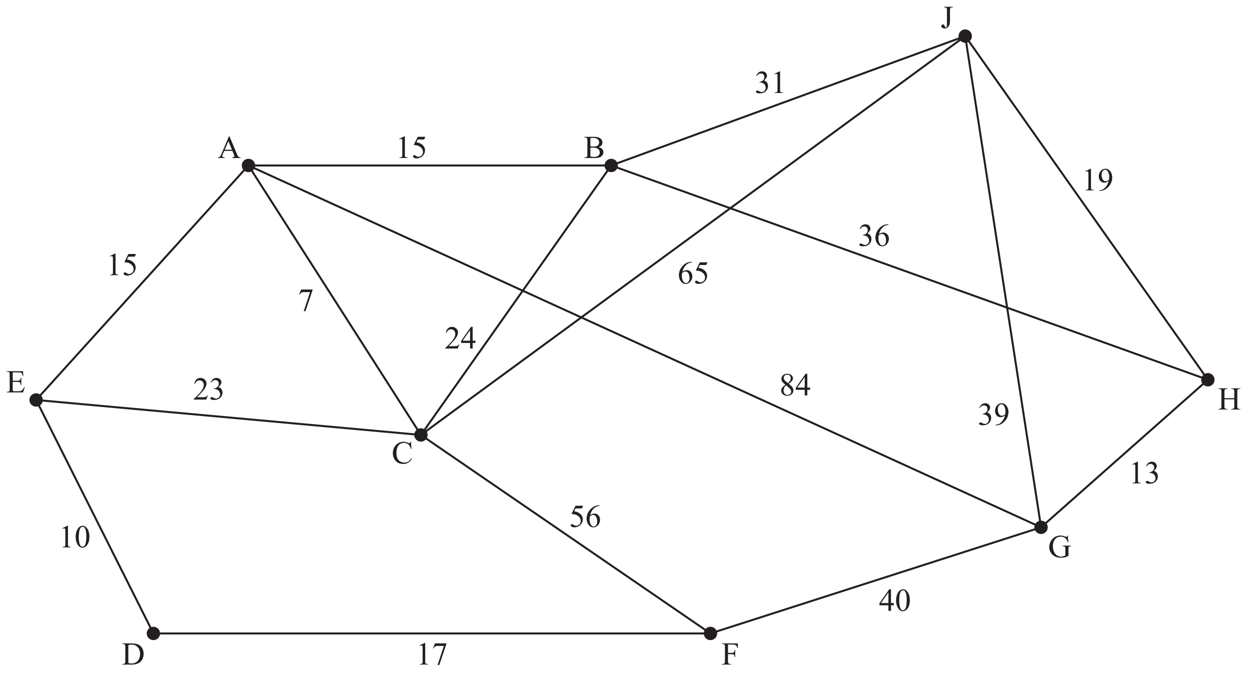

Figure 3

[*The total weight of the network is* 494]

Direct roads between nine factories, A, B, C, D, E, F, G, H and J, are represented in Figure 3.

The number on each arc represents the lengths, in kilometres, of the corresponding road.

The table below shows the shortest distances, in kilometres, between the nine factories.

	A	B	C	D	E	F	G	H	J
A	-	15	7	25	15	42	64	51	46
B	15	-	22	40	30	57	49	36	31
C	7	22	-	32	22	49	71	58	53
D	25	40	32	-	10	17	57	70	71
E	15	30	22	10	-	27	67	66	61
F	42	57	49	17	27	-	40	53	72
G	64	49	71	57	67	40	-	13	32
H	51	36	58	70	66	53	13	-	19
J	46	31	53	71	61	72	32	19	-

Table of shortest distances

(a) Starting at A, use Prim's algorithm to find a minimum spanning tree for the table of shortest distances. You must state the order in which you select the arcs of your tree.

(3)

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

(1)

A route is needed that minimises the total distance to traverse each road at least once. The route must start at E and finish at F.

(c) Determine the length of this route. You must give a reason for your answer.

(2)

It is now decided to start the route at C and finish the route at A. The route must include every road at least once and must still minimise the total distance travelled.

(d) By considering the pairings of all relevant nodes, find the roads that need to be traversed twice.

(4)

Naoko needs to visit all nine factories, starting and finishing at the same factory, and wishes to minimise the total distance travelled.

(e) Starting at B, use the nearest neighbour algorithm on the table of shortest distances to find an upper bound for the length of Naoko's route. Write down the cycle, obtained from the table of shortest distances, which gives this upper bound.

(2)

(f) By deleting C and all of its arcs, use the values in the table of shortest distances to find a lower bound for the length of Naoko's route.

(2)

(Total for Question 4 is 14 marks)

5. The head of a Mathematics department needs to order three types of paper. The three types of paper are plain, lined and graph.

All three types of paper are sold in reams. (A ream is 500 sheets of paper.)

Based on the last academic year the head of department formed the following constraints.

- At least half the paper must be lined
- No more than 15% of the paper must be graph paper
- The ratio of plain paper to graph paper must be 5 : 2

The cost of each ream of plain, lined and graph paper is £5, £12 and £15 respectively. The head of department has at most £834 to spend on paper.

The head of department wants to maximise the total number of reams of paper ordered.

Let x, y and z represent the number of reams of plain paper, lined paper and graph paper ordered respectively.

(a) Formulate this information as a linear programming problem in x and y only, stating the objective and listing the constraints as simplified inequalities with integer coefficients.

(7)

The head of department decides to order exactly 42 reams of lined paper and still wishes to maximise the total number of reams of paper ordered.

(b) Determine

(i) the total number of reams of paper to be ordered,

(ii) the number of reams of graph paper to be ordered.

(3)

(Total for Question 5 is 10 marks)

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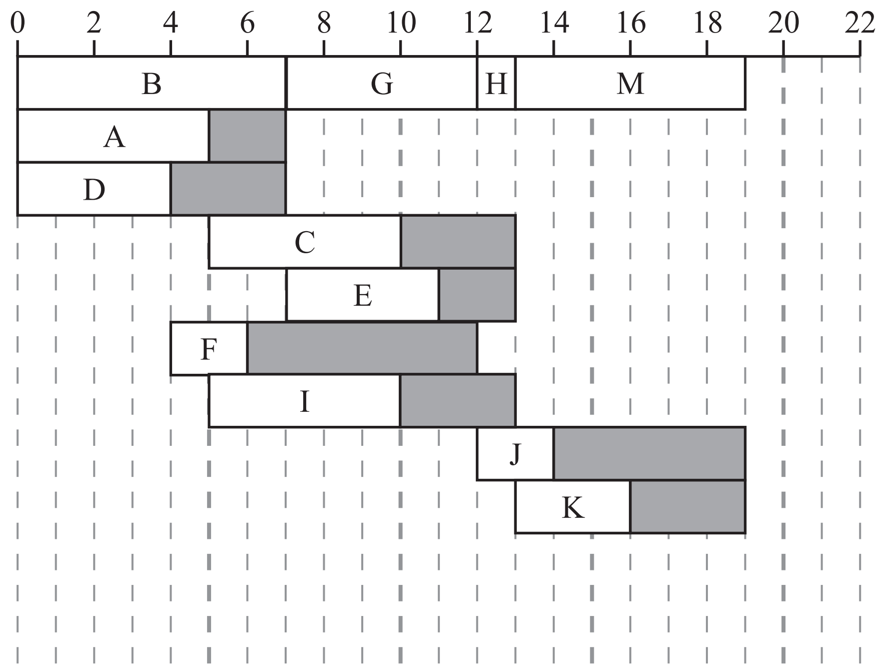
6.

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

(a) Draw the activity network for the project described in the precedence table, using activity on arc and the minimum number of dummies.

(5)



Grid 1

A cascade chart for all the activities of the project, **except activity L**, is shown on Grid 1.

The time taken to complete each activity is given in hours and each activity requires one worker.

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

(b) State the critical activities of the project.

(1)

(c) Use the cascade chart to determine the minimum number of workers needed to complete the project in the shortest possible time. You must make specific reference to time and activities. (You do **not** need to provide a schedule of the activities.)

(2)

The duration of activity L is x hours. Given that the total float of activity L is at most 7 hours,

(d) determine the range of possible values for x.

(2)

(Total for Question 6 is 10 marks)

7.

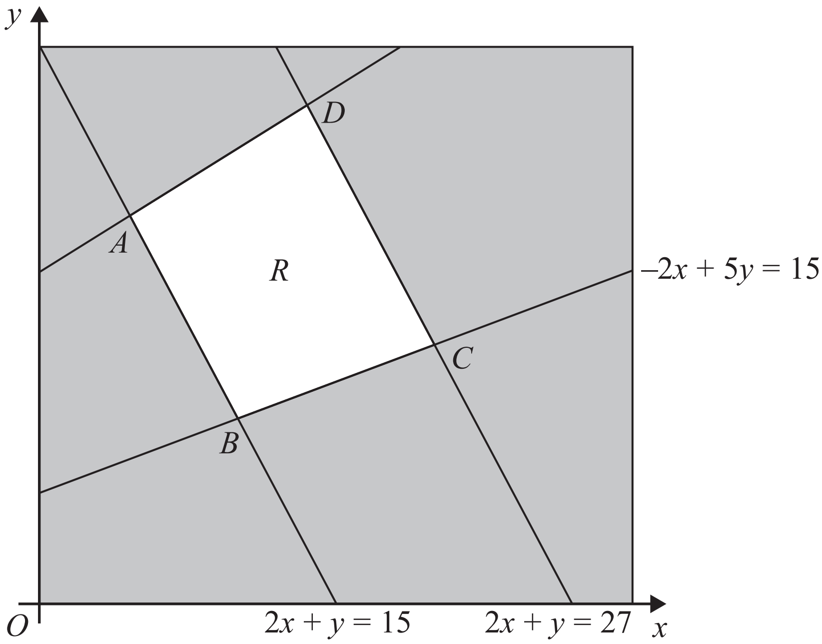


Figure 4

Figure 4 shows the constraints of a linear programming problem in x and y, where R is the feasible region.

The equations of three of the lines, and the four intersection points, A, B, C and D, are shown.

The four vertices of R are $A\left(\frac{9}{4}, \frac{21}{2}\right)$, $B(5, 5)$, $C(10, 7)$ and $D\left(\frac{27}{4}, \frac{27}{2}\right)$.

(a) Determine the inequalities that define R.

(4)

The objective function, P, is given by

$$P = 2x + ky$$

where k is a positive constant.

Given that the minimum value of P is at least half of the maximum value of P,

(b) determine the range of possible values of k.

(5)

(Total for Question 7 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS

Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | | | | | |

Candidate Number | | | | |

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

Total Marks

Turn over ▶

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F:1/1/1/

P 7 4 3 0 6 A 0 1 2 0

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1.

5.2	4.7	6.5	4.5	3.1	5.1	1.8	2.9	3.4	3.8	1.2

P 7 4 3 0 6 A 0 2 2 0

Question 1 continued

Question 1 continued

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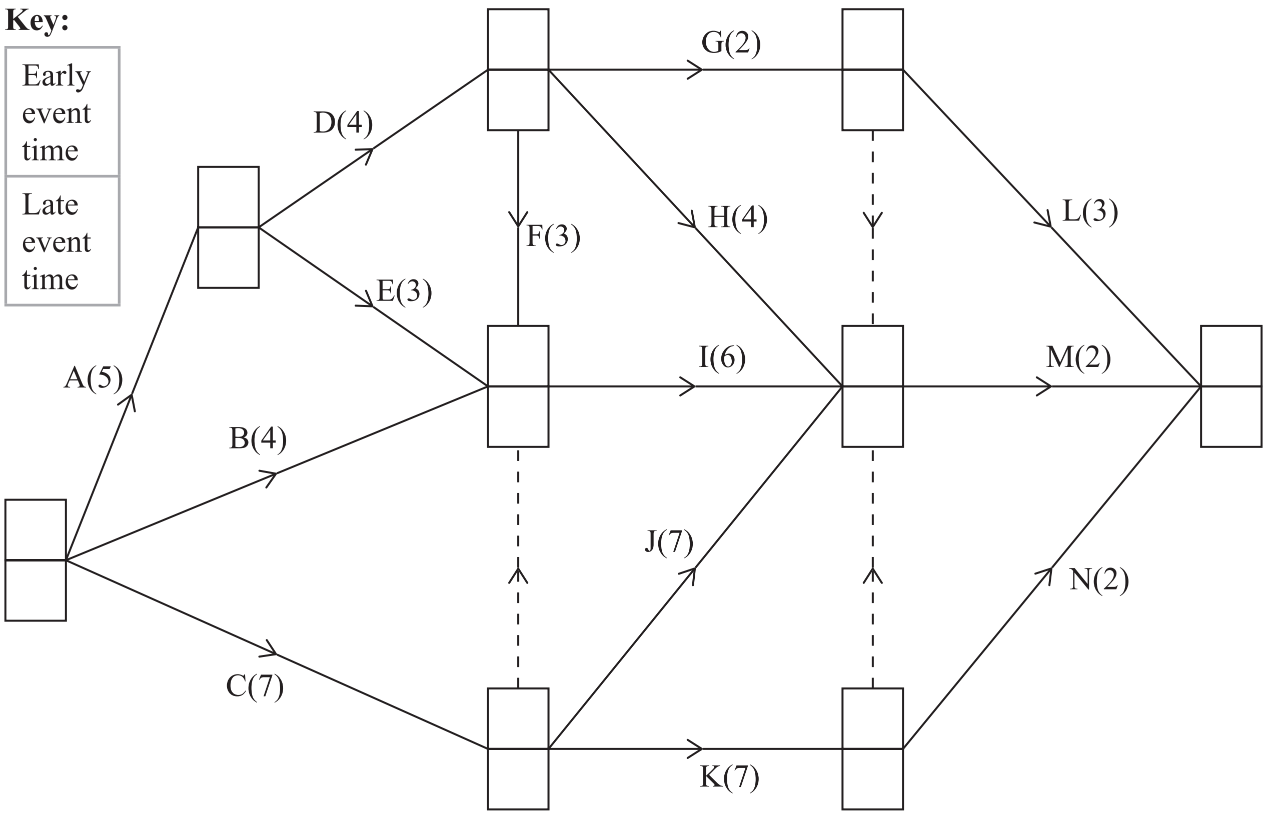
Question 1 continued

(Total for Question 1 is 14 marks)

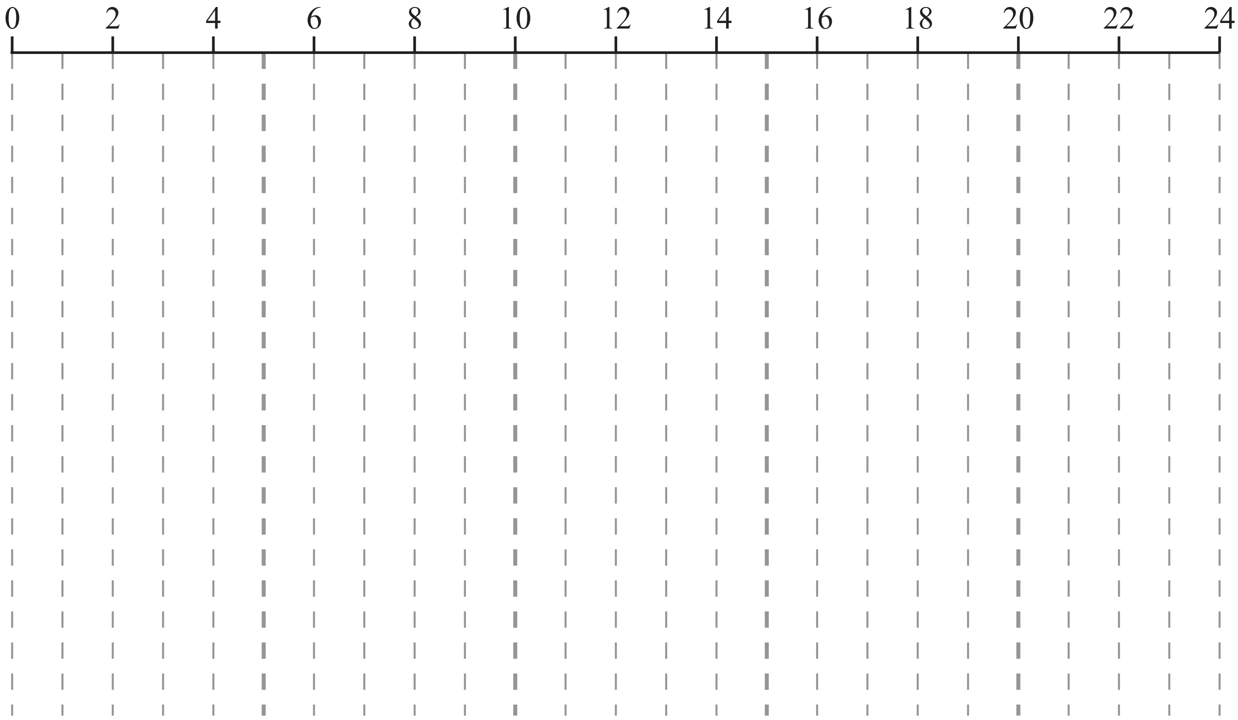
2.



Key:
Early event time
Late event time
A(5)
B(4)
C(7)
D(4)
E(3)
F(3)
G(2)
H(4)
I(6)
J(7)
K(7)
L(3)
M(2)
N(2)

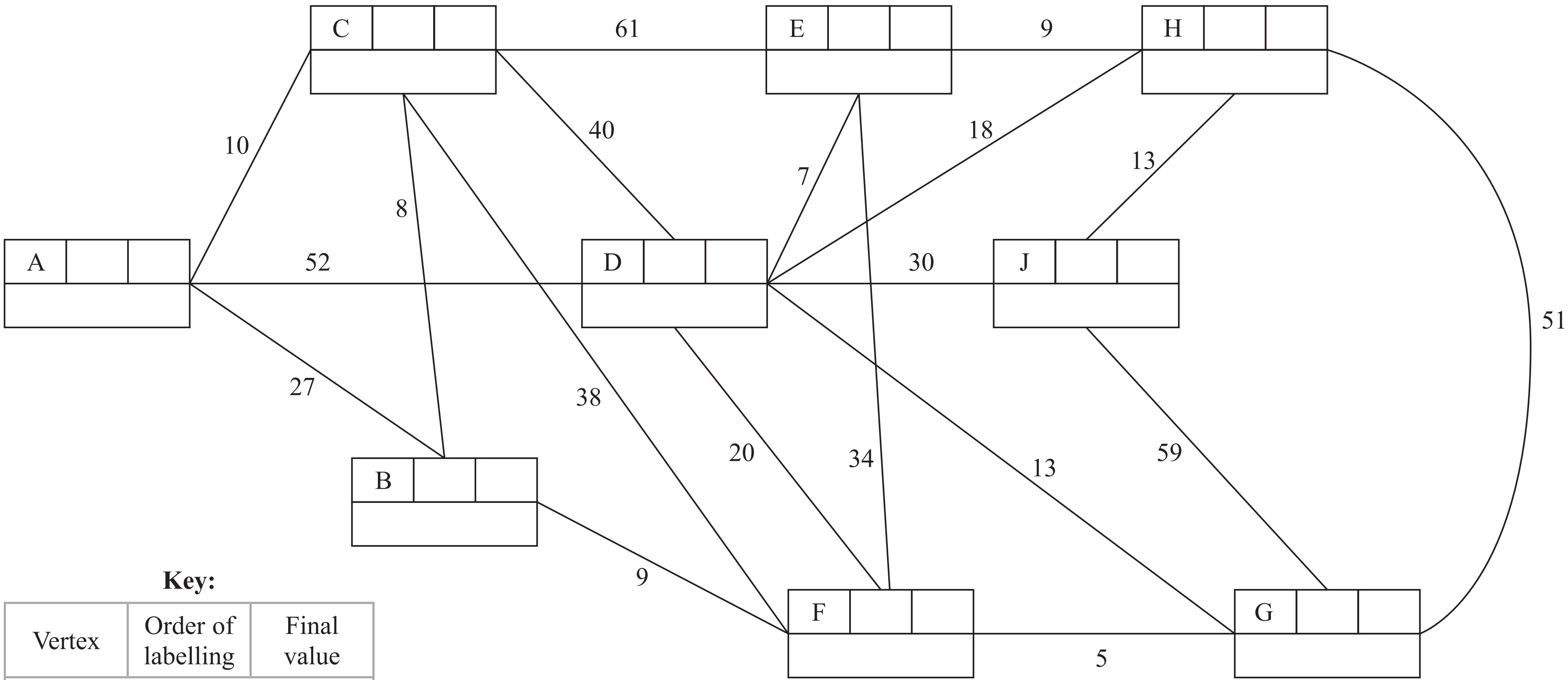
Diagram 1

Question 2 continued



(Total for Question 2 is 10 marks)

3.



Key:

Vertex	Order of labelling	Final value
Working values		

Shortest time to travel from A to J: ______________________

Quickest route from A to J: ______________________

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Question 3 continued

(Total for Question 3 is 8 marks)

4.

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Question 4 continued

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Question 4 continued

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Question 4 continued

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(Total for Question 4 is 14 marks)

5.

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Question 5 continued

(Total for Question 5 is 10 marks)

6.

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Question 6 continued

(Total for Question 6 is 10 marks)

7.

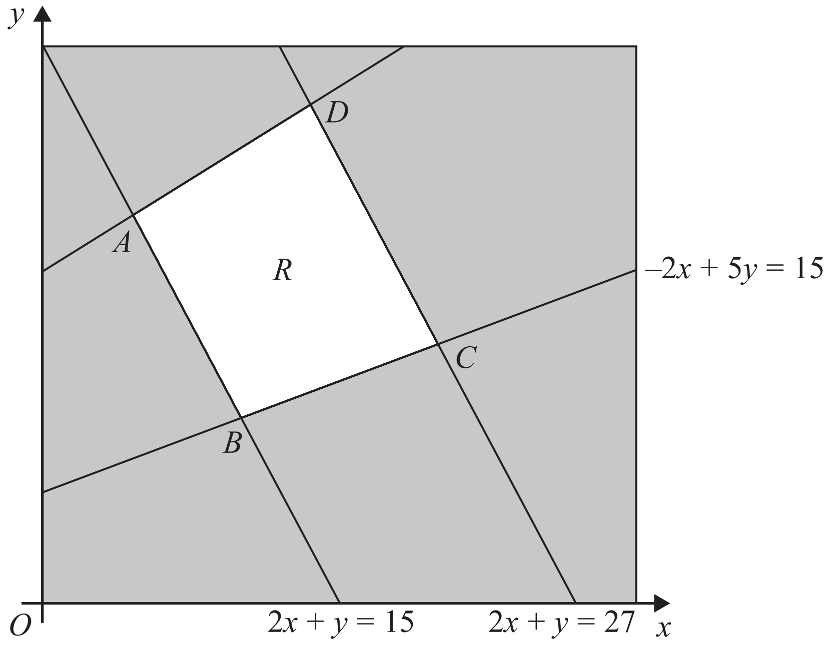

Figure 4

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Question 7 continued

Question 7 continued

(Total for Question 7 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS