Please check the examination details below before entering your candidate information

Candidate surname StemUp Model Solution | Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Time 1 hour 30 minutes

Paper reference WDM11/01

Mathematics

International Advanced Subsidiary/Advanced Level
Decision Mathematics D1

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

Total Marks

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P 7 1 9 8 0 R A 0 1 2 0

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1.

17 9 15 8 20 13 28 4 12 5

(a) 17 + 9 + 15 + 8 + 20 + 13 + 28 + 4 + 12 + 5 = 131

131 ÷ 40 = 3.275, so lower bound = 4 containers

(b) First-fit:

Container 1: 17 9 8 4

Container 2: 15 20 5

Container 3: 13 12

Container 4: 28

(c) Quick sort, pivot = middle right item of each sublist:

17	9	15	8	20	13	28	4	12	5	pivot 13
9	8	4	12	5	13	17	15	20	28	pivots 4, 20
4	9	8	12	5	13	15	17	20	28	pivots 12, 15, 28
4	9	8	5	12	13	15	17	20	28	pivots 8, 17
4	5	8	9	12	13	15	17	20	28	sort complete

(d) Sorted list: 4 5 8 9 12 13 15 17 20 28

Pivot 1: (1 + 10) ÷ 2 = 5.5 → 6th item = 13

9 < 13, so reject 13 to 28 (items 6 to 10)

Pivot 2: (1 + 5) ÷ 2 = 3 → 3rd item = 8

9 > 8, so reject 4 to 8 (items 1 to 3)

Pivot 3: (4 + 5) ÷ 2 = 4.5 → 5th item = 12

9 < 12, so reject 12 (item 5)

Pivot 4: (4 + 4) ÷ 2 = 4 → 4th item = 9

9 = 9, so 9 is found (item 4)

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Question 1 continued

Question 1 continued

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Question 1 continued

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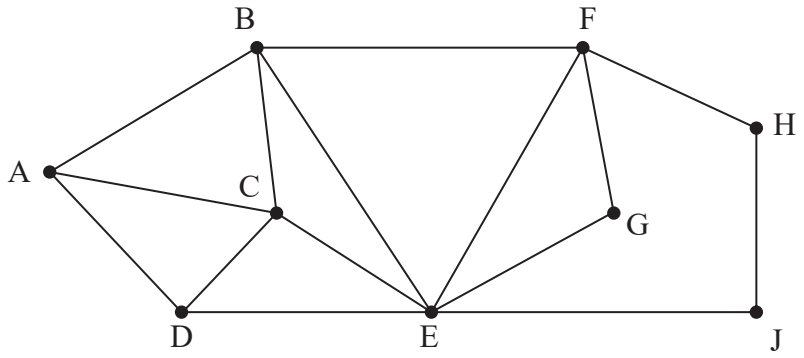


Figure 1

(a) A – B – F – H – J

(b) No. Although it visits every vertex, it does not finish at A:
a tour must start and finish at the same vertex.

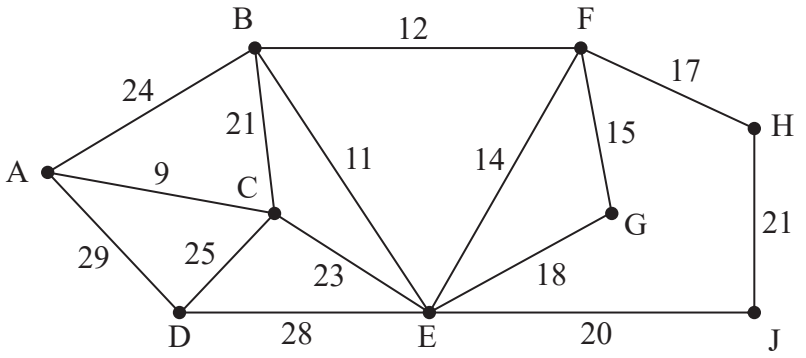


Figure 2

(c) Kruskal: AC (9) add, BE (11) add, BF (12) add,
EF (14) reject, FG (15) add, FH (17) add, EG (18) reject,
EJ (20) add, HJ (21) reject, BC (21) add, CE (23) reject,
AB (24) reject, CD (25) add
All 9 vertices are now connected (8 arcs), so stop.

(d) Minimum spanning tree drawn on Diagram 1 below.

(e) Weight = 9 + 11 + 12 + 15 + 17 + 20 + 21 + 25 = 130 km

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Question 2 continued

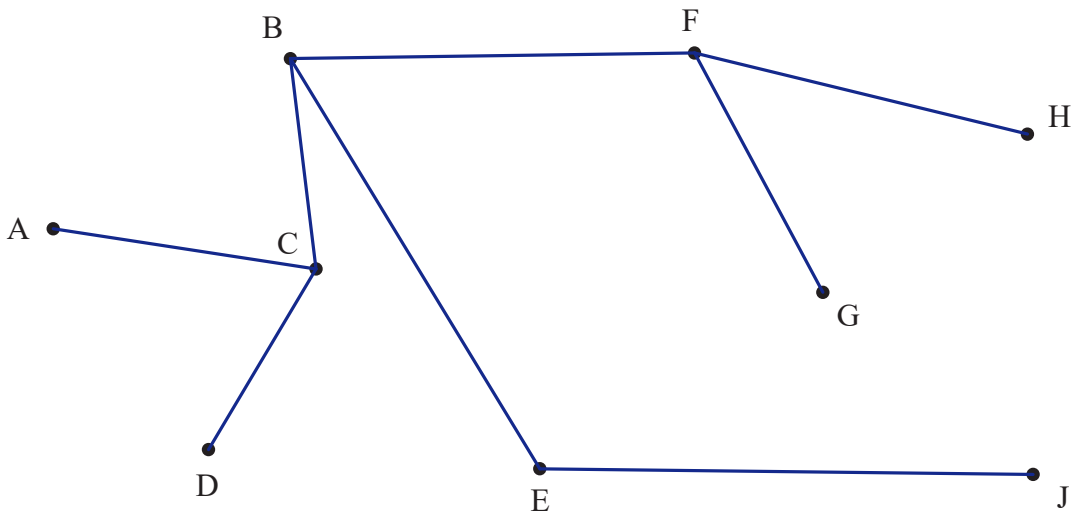


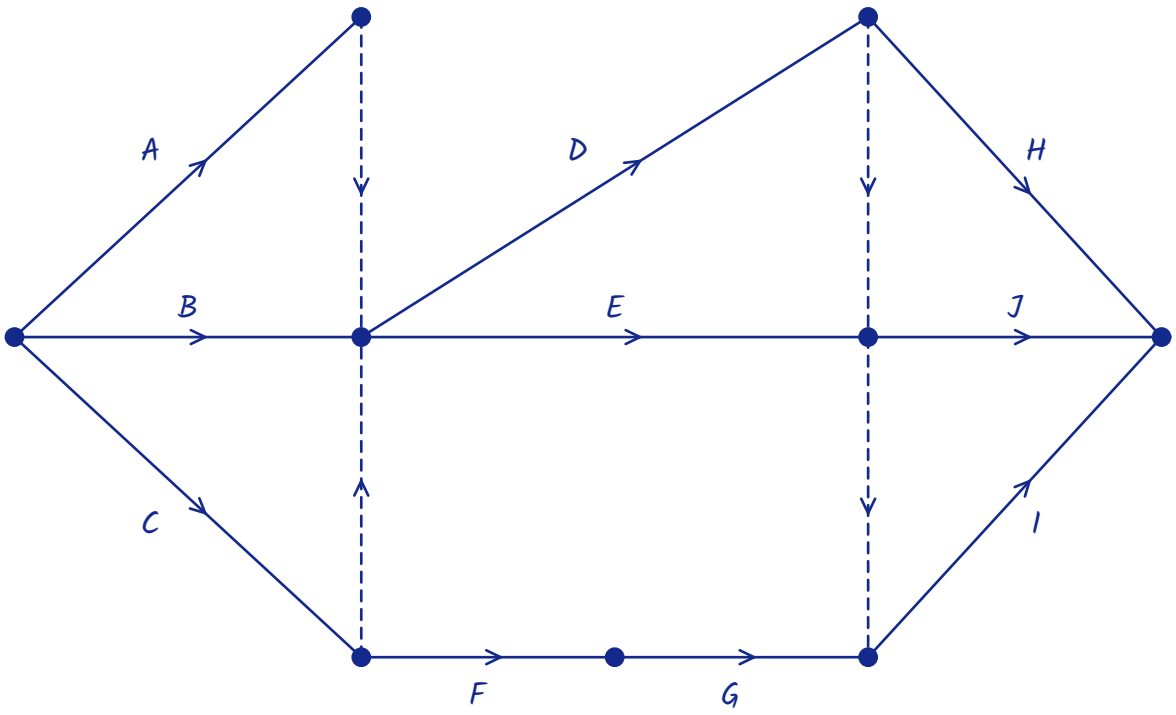
Diagram 1

Weight of the minimum spanning tree: 130 km

(Total 7 marks)

3.

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



(dashed arcs are dummies)

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Question 3 continued

Please redraw your activity network on this page if you need to do so.

(Total 5 marks)

4.

(a) Total float on D = 8 − 3 − x = 5 − x

Total float on F = 22 − 8 − y = 14 − y

Float on F = 2 × float on D: $14 - y = 2(5 - x)$

$\Rightarrow 14 - y = 10 - 2x \Rightarrow -2x + y = 4$

Critical path length = 26, so BDFM has length 26 − 10 = 16

$3 + x + y + 3 = 16 \Rightarrow x + y = 10$

Solving simultaneously: $y = 2x + 4$ and $x + y = 10$

$x + 2x + 4 = 10 \Rightarrow 3x = 6 \Rightarrow x = 2$

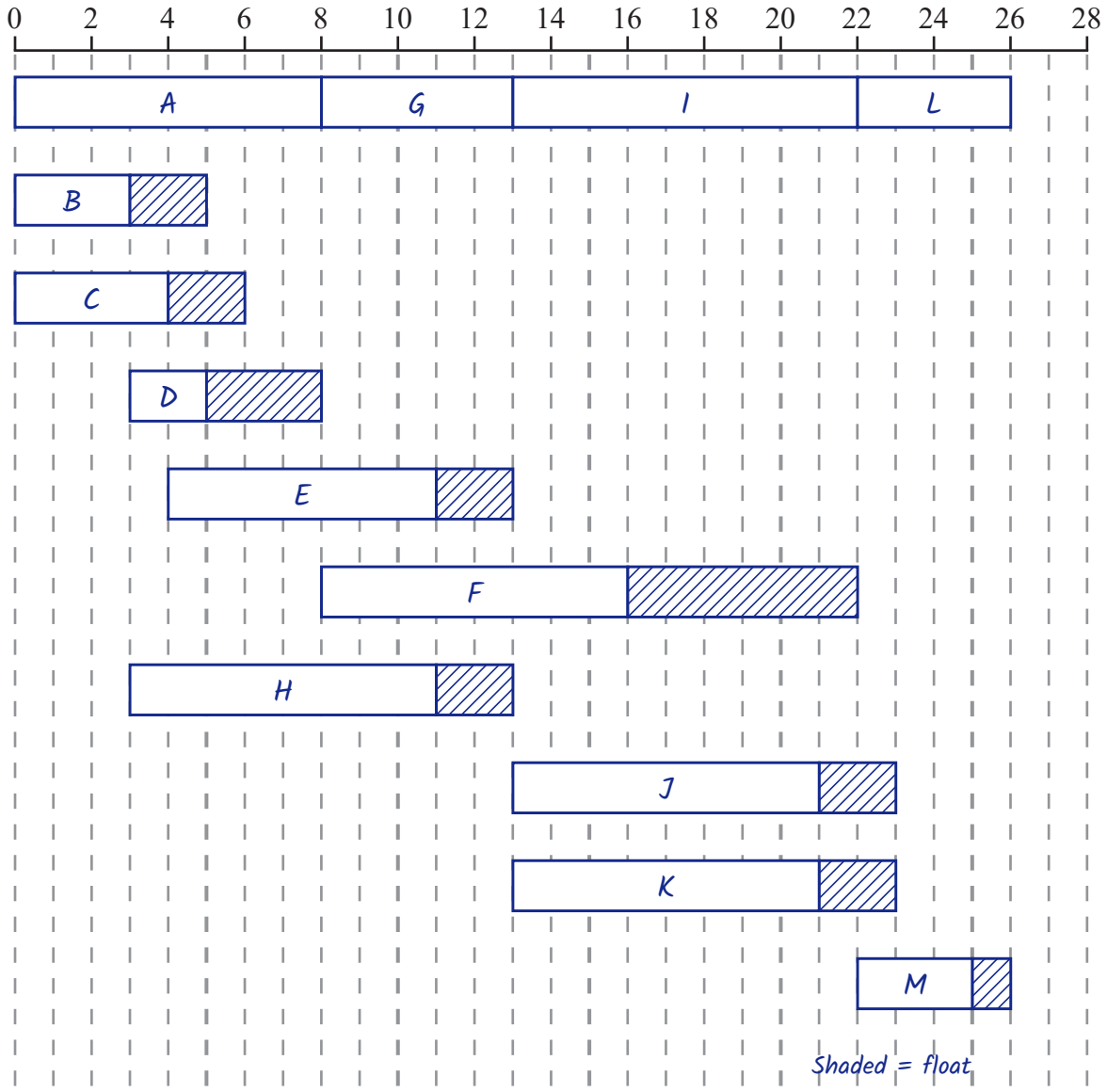
$y = 10 - 2 = 8$

$\therefore x = 2, \quad y = 8$

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Question 4 continued



Grid 1

(c) Between time 15 and time 16 (e.g. at time 15.5), activities F, I, J and K must all be happening at the same time, so at least 4 workers are needed.

Minimum number of workers = 4

(Total 10 marks)

5.

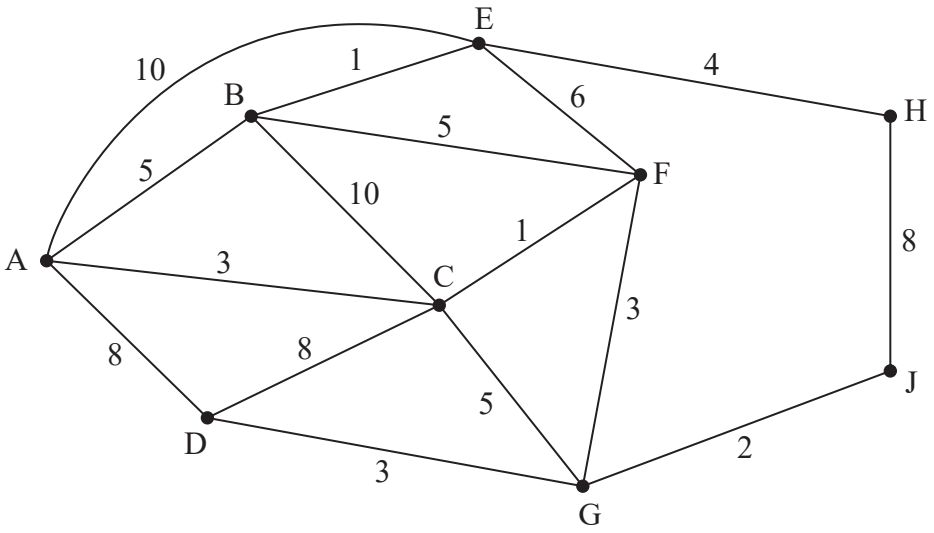


Figure 4

[*The total weight of the network is* 82]

(a) Odd vertices: C (degree 5) and D (degree 3)

Shortest C to D: CD = 8, CGD = 5 + 3 = 8, CFGD = 1 + 3 + 3 = 7

Least is 7 (C – F – G – D), so repeat arcs CF, FG and DG

Time = 82 + 7 = 89 minutes

Route e.g. G – D – G – J – H – E – A – D – C – A – B – E – F – B – C – F – C – G – F – G

(b) Start at B and finish at G, so B and G are now also odd:

relevant nodes are B, C, D and G.

BC + DG = 6 (BFC) + 3 (DG) = 9

BD + CG = 11 (BFGD) + 4 (CFG) = 15

BG + CD = 8 (BFG) + 7 (CFGD) = 15

Least is BC + DG = 9 (B – F – C and D – G)

Arcs traversed twice: BF, CF and DG

(c) Starting at B: 82 + 9 = 91 minutes

Starting at G: 89 minutes

91 – 89 = 2, so the route starting at G is quicker (by 2 minutes).

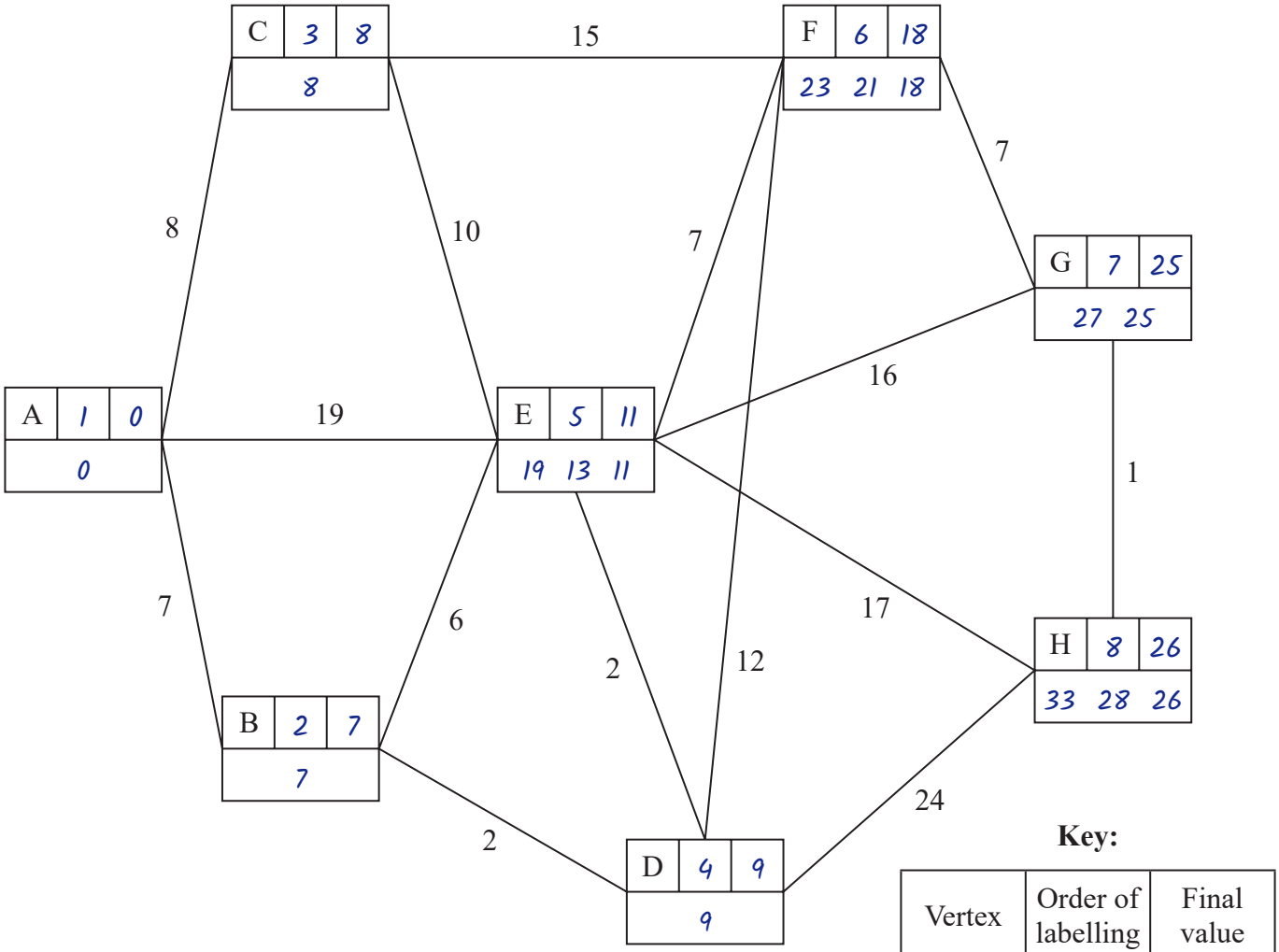
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Question 5 continued

(Total 10 marks)

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6.



	A	B	C	D	E	F	G	H
A	–	7	8	9	11	18	25	26
B	7	–	14	2	4	11	18	19
C	8	14	–	12	10	15	22	23
D	9	2	12	–	2	9	16	17
E	11	4	10	2	–	7	14	15
F	18	11	15	9	7	–	7	8
G	25	18	22	16	14	7	–	1
H	26	19	23	17	15	8	1	–

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Question 6 continued

(b) A – B – D – E – F – G – H – C – A

Length = 7 + 2 + 2 + 7 + 7 + 1 + 23 + 8 = 57 km

Upper bound = 57 km

(c)

	4	1	3	2	5	6	7
	B	C	D	E	F	G	H
B	–	14	(2)	4	11	18	19
C	14	–	12	10	15	22	23
D	2	12	–	(2)	9	16	17
E	4	(10)	2	–	7	14	15
F	11	15	9	(7)	–	7	8
G	18	22	16	14	(7)	–	1
H	19	23	17	15	8	(1)	–

(c)(i) Prim starting at C (order of vertices numbered above table):

Order of arcs: CE (10), DE (2), BD (2), EF (7), FG (7), GH (1)

Weight of RMST = 10 + 2 + 2 + 7 + 7 + 1 = 29

(ii) Two least arcs from A: AB (7) and AC (8)

Lower bound = 29 + 7 + 8 = 44 km

(d) 44 km ≤ length of optimal route ≤ 57 km

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Question 6 continued

(Total 14 marks)

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7.

(a) Minimise $C = 9x + 12y + 16z$

subject to:

$x + y + z \geqslant 40$

$z \geqslant 2y$

$x \leqslant 0.6(x + y + z) \Rightarrow 5x \leqslant 3x + 3y + 3z \Rightarrow 2x \leqslant 3y + 3z$

$x + 1.5y + 2.5z \leqslant 75 \Rightarrow 2x + 3y + 5z \leqslant 150$

$x \geqslant 0, \quad y \geqslant 0, \quad z \geqslant 0$

(b) $x + y + z = 45 \Rightarrow z = 45 - x - y$

$C = 9x + 12y + 16(45 - x - y)$

$= 9x + 12y + 720 - 16x - 16y$

$= 720 - 7x - 4y = 720 - (7x + 4y)$

720 is a constant, so C is minimised when $-(7x + 4y)$ is as small as possible. As $x, y \geqslant 0$, $7x + 4y$ is positive, so $-(7x + 4y)$ is smallest (most negative) when $7x + 4y$ is largest.

Minimising a negative expression is equivalent to maximising the corresponding positive expression, so the minimum total cost is achieved when $7x + 4y$ is maximised.

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Question 7 continued

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Question 7 continued

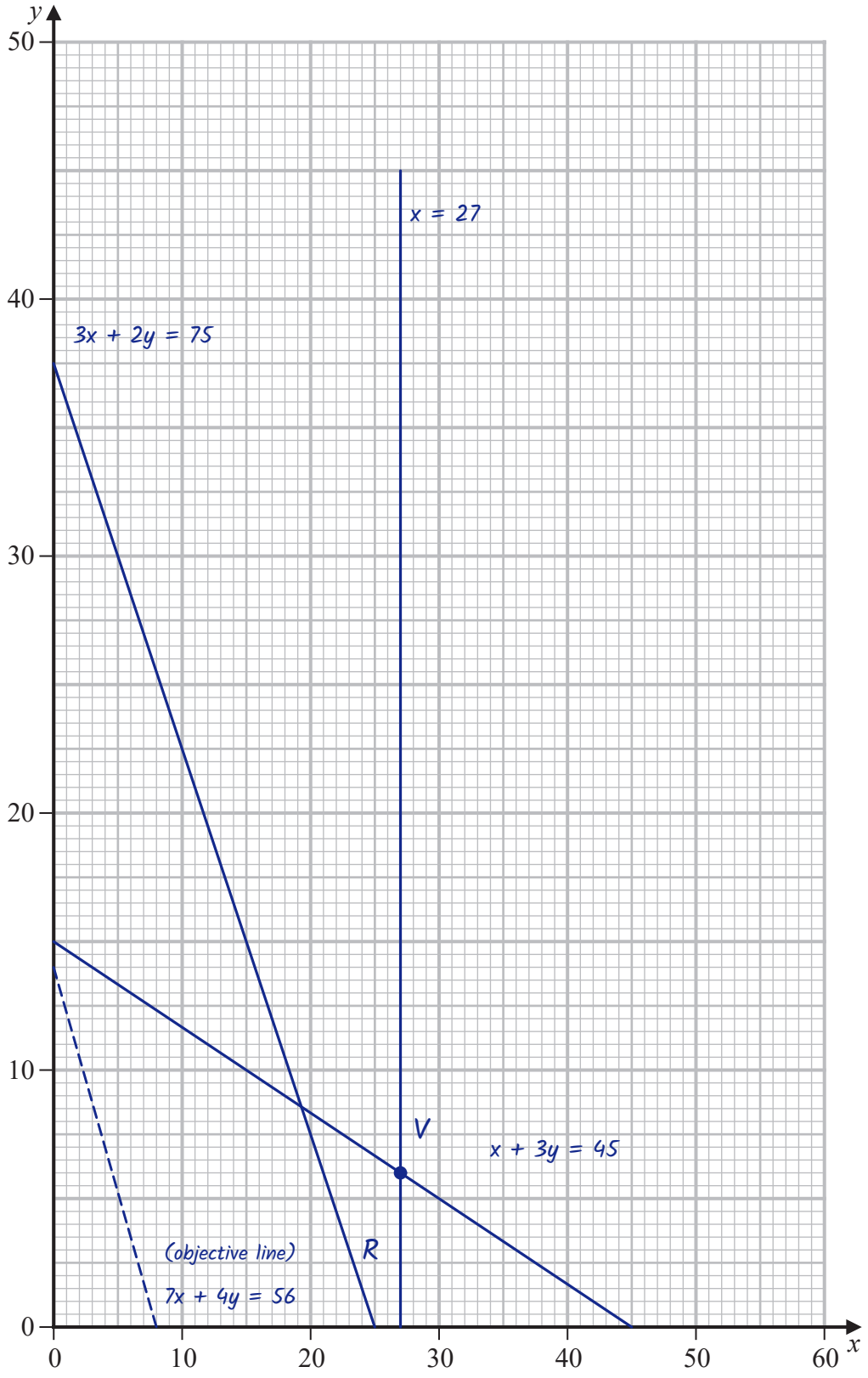


Diagram 1

Question 7 continued

(c) Lines $x + 3y = 45$, $x = 27$, $3x + 2y = 75$ drawn on Diagram 1;
feasible region R labelled.

(d) Objective line $7x + 4y = 56$ (gradient $-7/4$) drawn dashed.
Moving it parallel, away from O, the last vertex of R it
reaches is V = (27, 6).

(e) $x = 27$, $y = 6$, $z = 45 - 27 - 6 = 12$
27 small, 6 medium and 12 large containers
Total cost = $9(27) + 12(6) + 16(12)$
$= 243 + 72 + 192 = £507$

(Total 18 marks)

TOTAL FOR PAPER = 75 MARKS

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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.

Turn over ▶

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P 7 1 9 8 0 R A

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

1.

17 9 15 8 20 13 28 4 12 5

The numbers in the list shown above are the weights, in kilograms, of ten boxes.
The boxes are to be transported in containers that will each hold a maximum weight of 40 kilograms.

(a) Calculate a lower bound for the number of containers that will be needed to transport the boxes. You must show your working.

(2)

(b) Use the first-fit bin packing algorithm to allocate the boxes to the containers.

(3)

(c) Using the list provided, carry out a quick sort to produce a list of the weights in **ascending** order. You must make your pivots clear.

(3)

(d) Use the binary search algorithm to try to locate the weight of 9 in the sorted list. Clearly indicate how you choose your pivots and which part of the list is being rejected at each stage.

(3)

(Total 11 marks)

2.

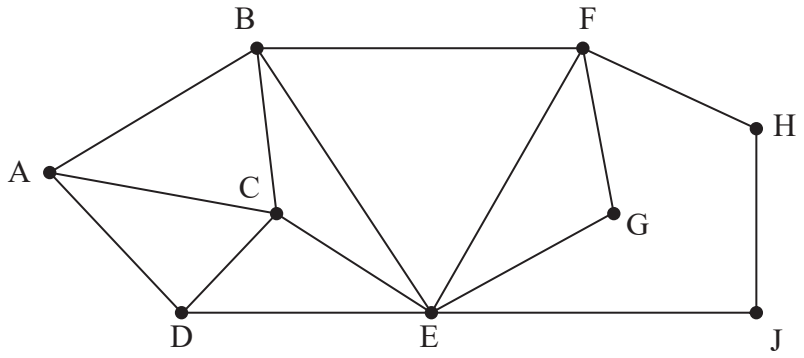


Figure 1

Figure 1 shows a graph, T.

(a) Write down an example of a path from A to J on T.

(1)

(b) State, with a reason, whether A – B – C – D – E – G – F – H – J is an example of a tour on T.

(1)

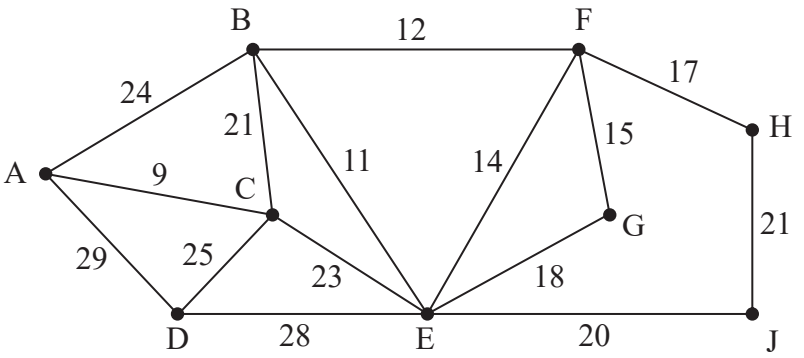


Figure 2

The numbers on the 15 arcs in Figure 2 represent the distances, in km, between nine vertices, A, B, C, D, E, F, G, H and J, in a network.

(c) 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 or not you are adding the arc to the minimum spanning tree.

(3)

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

(1)

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

(1)

(Total 7 marks)

3.

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

Draw the activity network described in the precedence table above, using activity on arc and exactly 4 dummies.

(5)

(Total 5 marks)

4.

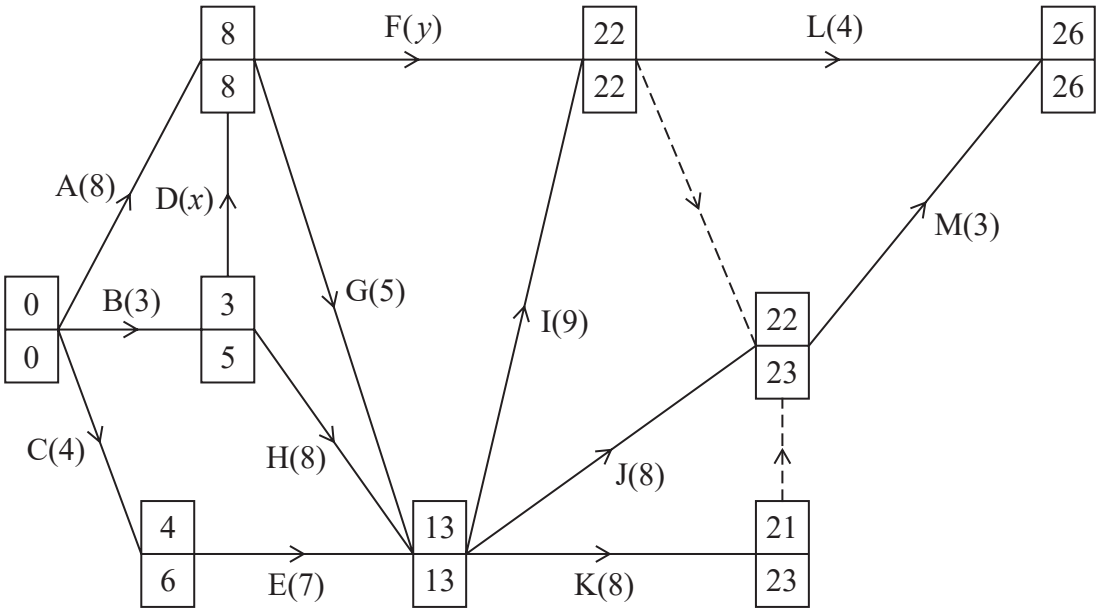


Figure 3

The network in Figure 3 shows the activities that need to be undertaken by a company to complete a project. Each activity is represented by an arc. The duration of the activity, in days, is shown in brackets. Each activity requires exactly one worker. The early event times and the late event times are shown at the vertices.

It is given that the total float on activity F is twice the total float on activity D.

It is also given that the total duration of the activities on the path BDFM is 10 days less than the duration of the critical path.

(a) Determine the value of x and the value of y. You must make your method and working clear.

(4)

(b) Draw a cascade chart for this project on Grid 1 in the answer book.

(4)

(c) Use your 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)

(Total 10 marks)

5.

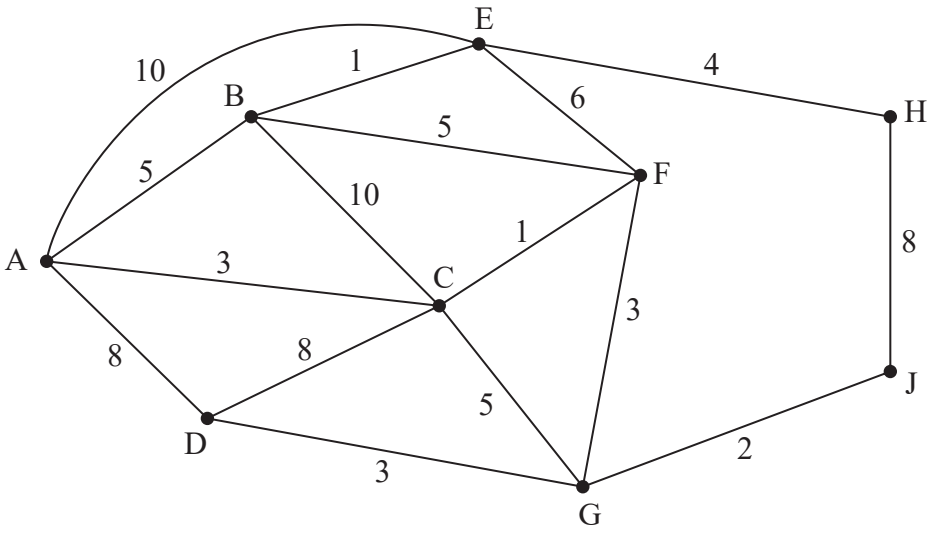


Figure 4

[*The total weight of the network is* 82]

Figure 4 represents a network of 16 roads in a city. The number on each arc represents the time taken, in minutes, to travel along the corresponding road.

Chan needs to check that the roads are in good repair. He must travel along each road at least once. Chan will start and finish at his office at G and must minimise the total time taken for his inspection route.

For this inspection route,

(a) find the time taken and state a possible route. You must make your method and reasoning clear.

(3)

Chan wonders if he can reduce his travel time by starting from his home at B, travelling along each road at least once and finishing at his office at G.

(b) By considering the pairings of all relevant nodes, find any arcs that would need to be traversed twice in the minimum inspection route from B to G. You must make your method clear, showing your working.

(5)

(c) Determine which of the two routes ending at G is quicker, the one starting at G or the one starting at B. You must justify your answer.

(2)

(Total 10 marks)

6.

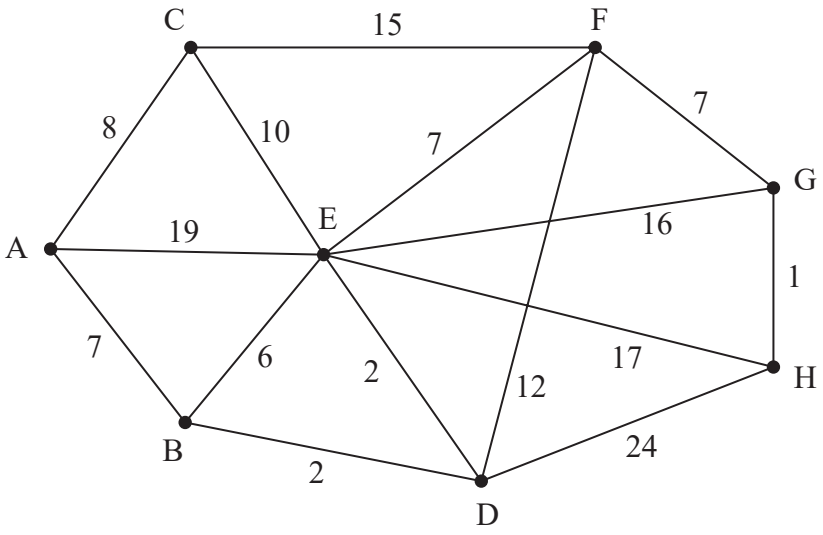


Figure 5

Figure 5 models a network of roads. The number on each edge gives the length, in km, of the corresponding road. The vertices, A, B, C, D, E, F, G and H, represent eight towns. Bronwen needs to visit each town. She will start and finish at A and wishes to minimise the total distance travelled.

(a) By applying Dijkstra's algorithm, starting at A, complete the table of least distances in the answer book.

(6)

(b) Starting at A, use the nearest neighbour algorithm to find an upper bound for the length of Bronwen's route. Write down the route that gives this upper bound.

(2)

A reduced network is formed by deleting A and all arcs that are directly joined to A.

(c) (i) Use Prim's algorithm, starting at C, to construct a minimum spanning tree for the reduced network. You must clearly state the order in which you select the arcs of your tree.

(ii) Hence, calculate a lower bound for the length of Bronwen's route.

(4)

(d) Using only the results from (b) and (c), write down the smallest interval that you can be confident contains the length of Bronwen's optimal route.

(2)

(Total 14 marks)

7. A company makes three types of storage container, small, medium and large.

The company owner knows that each week she should make

- at least 40 containers in total
- at least twice as many large containers as medium containers
- at most 60% small containers

Each small container requires 1 hour to make, each medium container requires 1.5 hours to make, and each large container requires 2.5 hours to make. The company has a total of 75 hours per week available to make all the containers.

Each small container costs £9 to make, each medium container costs £12 to make and each large container costs £16 to make.

The company owner wants to minimise her total cost.

- Let x represent the number of small containers made
- Let y represent the number of medium containers made
- Let z represent the number of large containers made

(a) Formulate this information as a linear programming problem. State the objective and list the constraints as simplified inequalities with integer coefficients.

(7)

The company owner now decides to make exactly 45 containers.

(b) Explain why the minimum total cost is achieved when $7x + 4y$ is maximised.

(3)

The requirement to make exactly 45 containers reduces the constraints of the problem to the following:

$$x + 3y \leqslant 45$$

$$0 \leqslant x \leqslant 27$$

$$3x + 2y \geqslant 75$$

$$y \geqslant 0$$

(c) Represent these constraints on Diagram 1 in the answer book. Hence determine, and label, the feasible region, R.

(4)

(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 V.

(2)

(e) Write down the number of each type of container the company should make. Calculate the corresponding total cost.

(2)

(Total 18 marks)

TOTAL FOR PAPER = 75 MARKS

END