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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J:1/1/1/1/1/1/

P 6 3 1 5 4 A 0 1 2 0

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1.

	A	B	C	D	E	F	G
A	–	43	52	47	59	53	55
B	43	–	59	45	46	52	47
C	52	59	–	51	50	55	51
D	47	45	51	–	52	49	55
E	59	46	50	52	–	57	48
F	53	52	55	49	57	–	55
G	55	47	51	55	48	55	–

(a) Nearest neighbour starting at A:

AB (43), BD (45), DF (49)

From F: FC = 55 and FG = 55 (a tie), so two routes.

Route 1: A – B – D – F – C – E – G – A

43 + 45 + 49 + 55 + 50 + 48 + 55 = 345 m

Route 2: A – B – D – F – G – E – C – A

43 + 45 + 49 + 55 + 48 + 50 + 52 = 342 m

(b) Delete A. Minimum spanning tree of B, C, D, E, F, G

(Prim from B): BD (45), BE (46), BG (47), DF (49), CE (50)

RMST weight = 45 + 46 + 47 + 49 + 50 = 237 m

Two least arcs from A: AB (43) and AD (47)

Lower bound = 237 + 43 + 47 = 327 m

(c) 327 m ≤ optimal length ≤ 342 m

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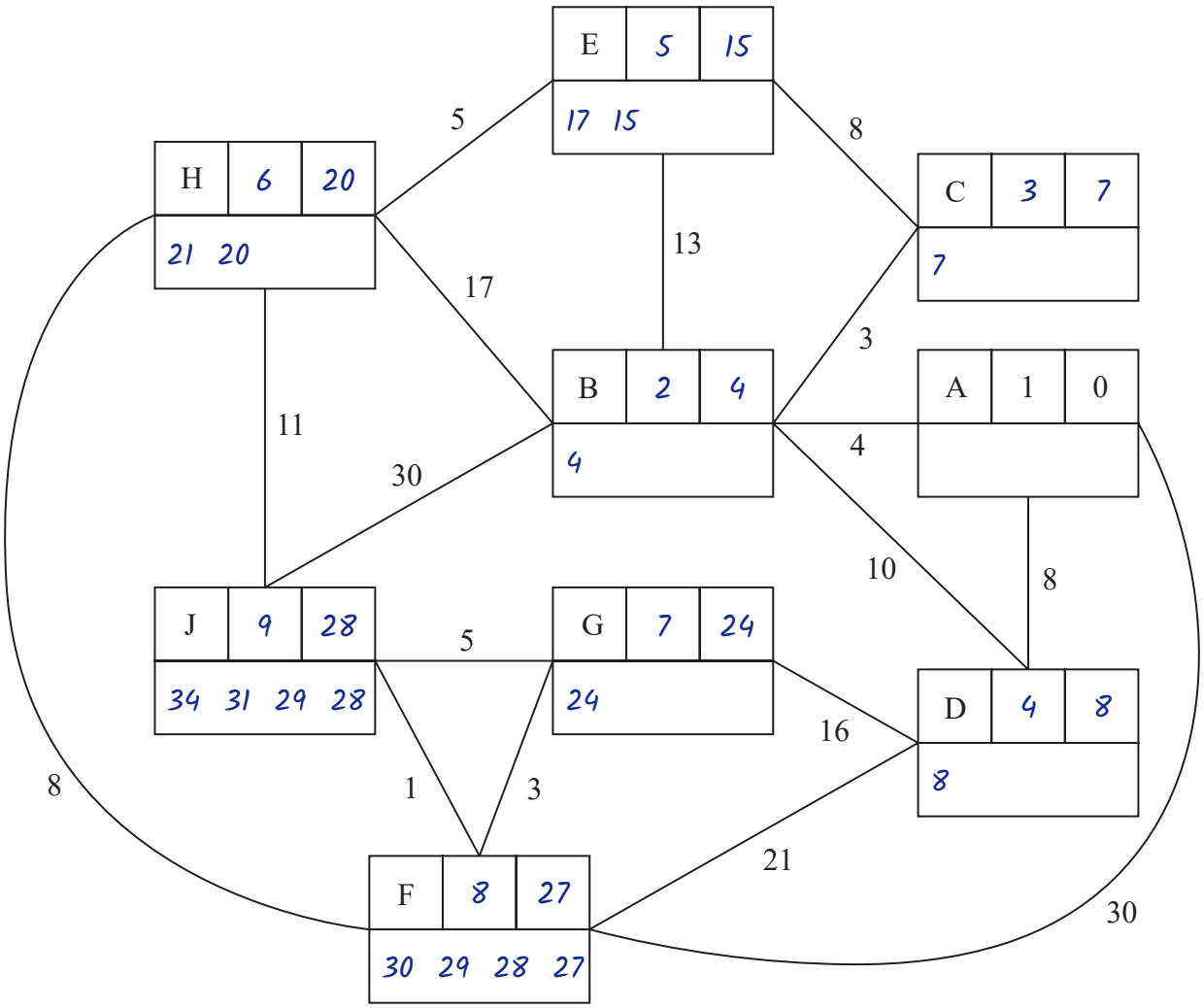
Question 1 continued

	A	B	C	D	E	F	G
A	–	43	52	47	59	53	55
B	43	–	59	45	46	52	47
C	52	59	–	51	50	55	51
D	47	45	51	–	52	49	55
E	59	46	50	52	–	57	48
F	53	52	55	49	57	–	55
G	55	47	51	55	48	55	–

(Total for Question 1 is 7 marks)

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2.



Key:

Vertex	Order of labelling	Final value
Working values		

Shortest path from A to J: A – D – G – F – J

Length of shortest path from A to J: 28 miles

(b) J to A is the reverse of (a): J – F – G – D – A = 28

A to H: A – B – C – E – H = 4 + 3 + 8 + 5 = 20

Shortest path: J – F – G – D – A – B – C – E – H

Length = 28 + 20 = 48 miles

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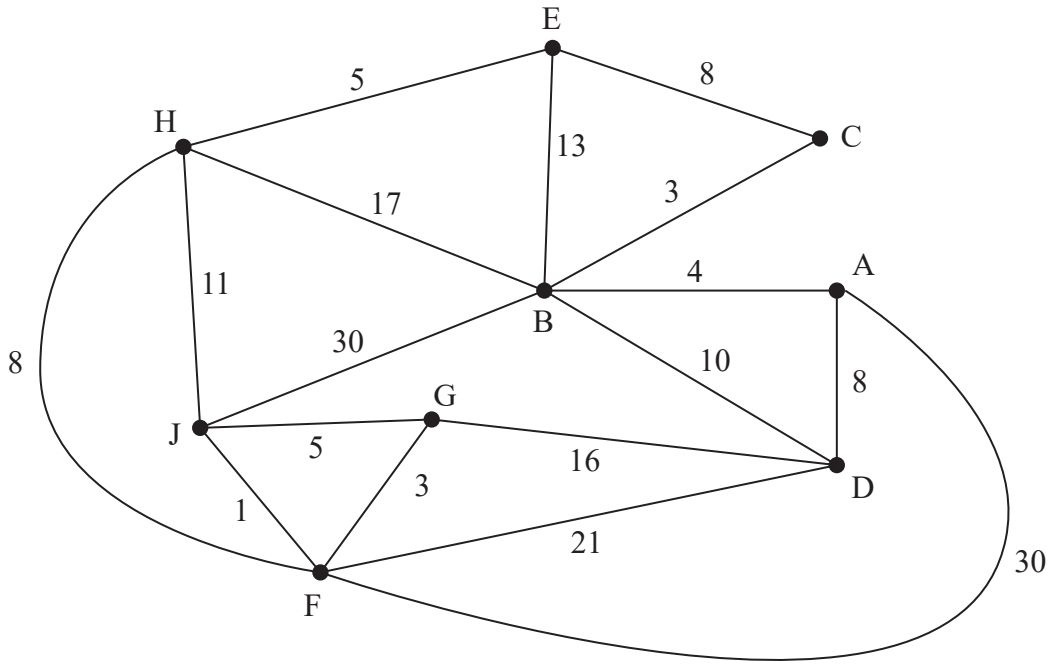


Figure 1

[*The total weight of the network is* 193]

(c) Odd vertices: A (3), E (3), F (5), G (3)

AE + FG = 15 (ABCE) + 3 (FG) = 18 ← least

AF + EG = 27 (ADGF) + 16 (EHFG) = 43

AG + EF = 24 (ADG) + 13 (EHF) = 37

Repeat arcs: AB, BC, CE and FG

Length = 193 + 18 = 211 miles

(d) Starting at G, G is one end of the route, so only one pair from the other odd vertices A, E, F is repeated:

AE = 15, AF = 27, EF = 13

EF (13) is the shortest path between two odd vertices not including G, so repeat EF (via H).

The route finishes at the remaining odd vertex, A.

Length = 193 + 13 = 206 miles

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Question 2 continued

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Question 2 continued

(Total for Question 2 is 16 marks)

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3.

1.8 1.4 2.6 1.6 2.8 0.9 3.1 0.8 1.2 2.4 0.6

(a) First-fit, bins of size 5:

Bin 1: 1.8 1.4 1.6

Bin 2: 2.6 0.9 0.8 0.6

Bin 3: 2.8 1.2

Bin 4: 3.1

Bin 5: 2.4

(b)(i) After the first pass:

1.8 2.6 1.6 2.8 1.4 3.1 0.9 1.2 2.4 0.8 0.6

(ii) Comparisons = 10, Swaps = 6

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

2.6	1.8	2.8	1.6	3.1	1.4	1.2	2.4	0.9	0.8	0.6	pivot 1.4
2.6	1.8	2.8	1.6	3.1	2.4	1.4	1.2	0.9	0.8	0.6	pivots 1.6, 0.8
2.6	1.8	2.8	3.1	2.4	1.6	1.4	1.2	0.9	0.8	0.6	pivots 2.8, 0.9, 0.6
3.1	2.8	2.6	1.8	2.4	1.6	1.4	1.2	0.9	0.8	0.6	pivots 3.1, 1.8, 1.2
3.1	2.8	2.6	2.4	1.8	1.6	1.4	1.2	0.9	0.8	0.6	pivot 2.4
3.1	2.8	2.6	2.4	1.8	1.6	1.4	1.2	0.9	0.8	0.6	sort complete

(d) First-fit decreasing, bins of size 5:

Bin 1: 3.1 1.8

Bin 2: 2.8 1.6 0.6

Bin 3: 2.6 2.4

Bin 4: 1.4 1.2 0.9 0.8

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Question 3 continued

Question 3 continued

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Question 3 continued

(Total for Question 3 is 13 marks)

4.

Activity	Immediately preceded by
A	–
B	–
C	–
D	A
E	C
F	C

Activity	Immediately preceded by
G	A, B, E
H	A, B, E
I	A, B, E
J	A, B, E, F
K	D, G
L	D, G

Activity	Immediately preceded by
M	D, G
N	H, K
P	H, K
Q	H, I, J, K
R	P, Q

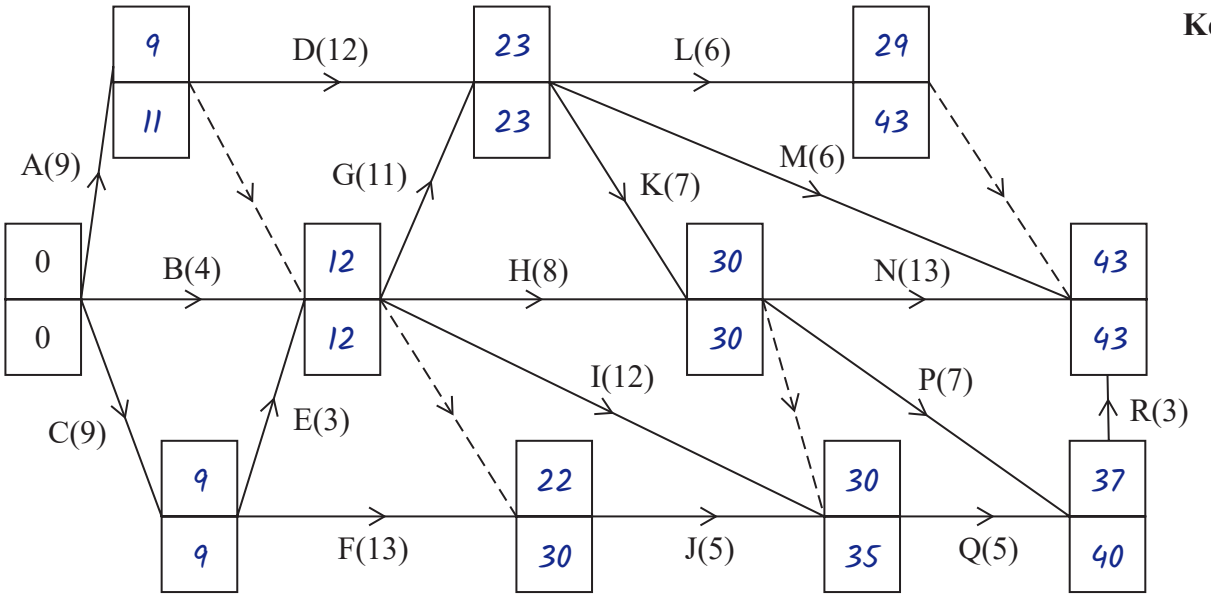


Diagram 1

(c) Critical activities: C, E, G, K and N

(d) Total float on J = 35 – 22 – 5 = 8 days

(e) Lower bound = 133 ÷ 43 = 3.0930...
so at least 4 workers are needed

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Question 4 continued

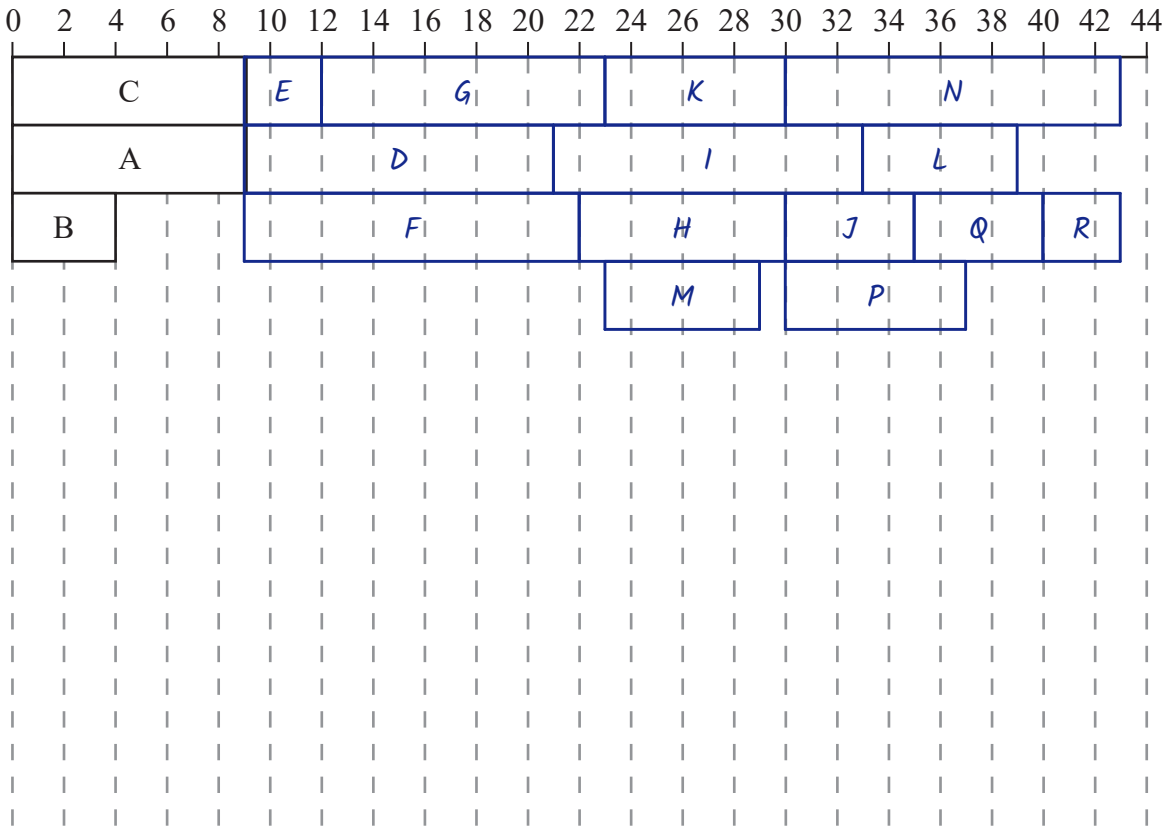


Diagram 2

(Total for Question 4 is 13 marks)

5.

(a) Sum of vertex orders = 1 + 2 + 2 + 3 + 3 + 4 + 4 + 6 = 25

The sum of the vertex orders must be even (it equals 2 × number of arcs), but 25 is odd. (Equivalently the graph would have an odd number of odd vertices.) So it is impossible.

(b) No, it is not a path, because vertex C appears twice (the route contains the cycle C – D – E – C).

(c) Prim starting at A; arcs in the order selected:

AC (16), AB (17), CD (18), DH (17), DG (20), CF (21), DE (24)

Weight of MST = 133 km

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Question 5 continued

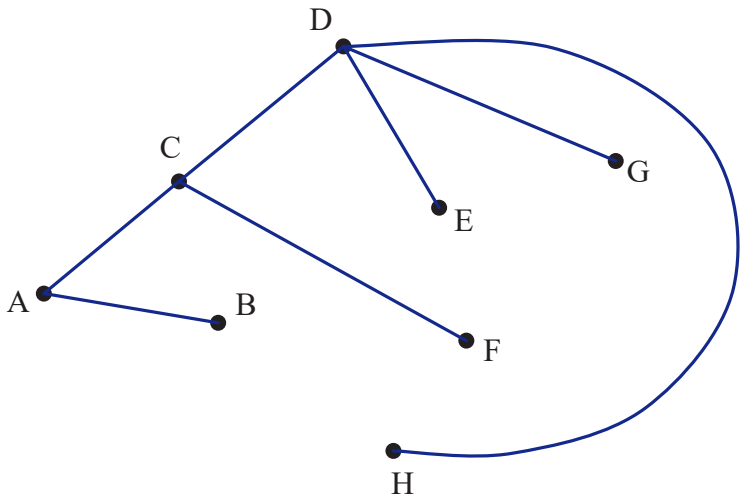


Diagram 1

(e) CF is increased from 21, so $x > 21$

If $x \geq 25$, F would join the tree by HF (25) instead of CF,

so $x < 25$ for CF to be in the unique MST.

$\therefore \ 21 < x < 25$

(Total for Question 5 is 9 marks)

6.

(a) Minimise $P = 300x + 400y + 400z$

subject to:

$275x + 200y + 100z \leq 5500 \Rightarrow 11x + 8y + 4z \leq 220$

$5x + 2y + 3z \leq 70$

$\frac{x}{15} + \frac{y}{20} + \frac{z}{30} \leq 1 \Rightarrow 4x + 3y + 2z \leq 60$

$x + y + z \geq 18$

$x, y, z \geq 0$

(b) Martin makes twice as many apple cakes as chocolate cakes (apple : chocolate = 2 : 1).

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Question 6 continued

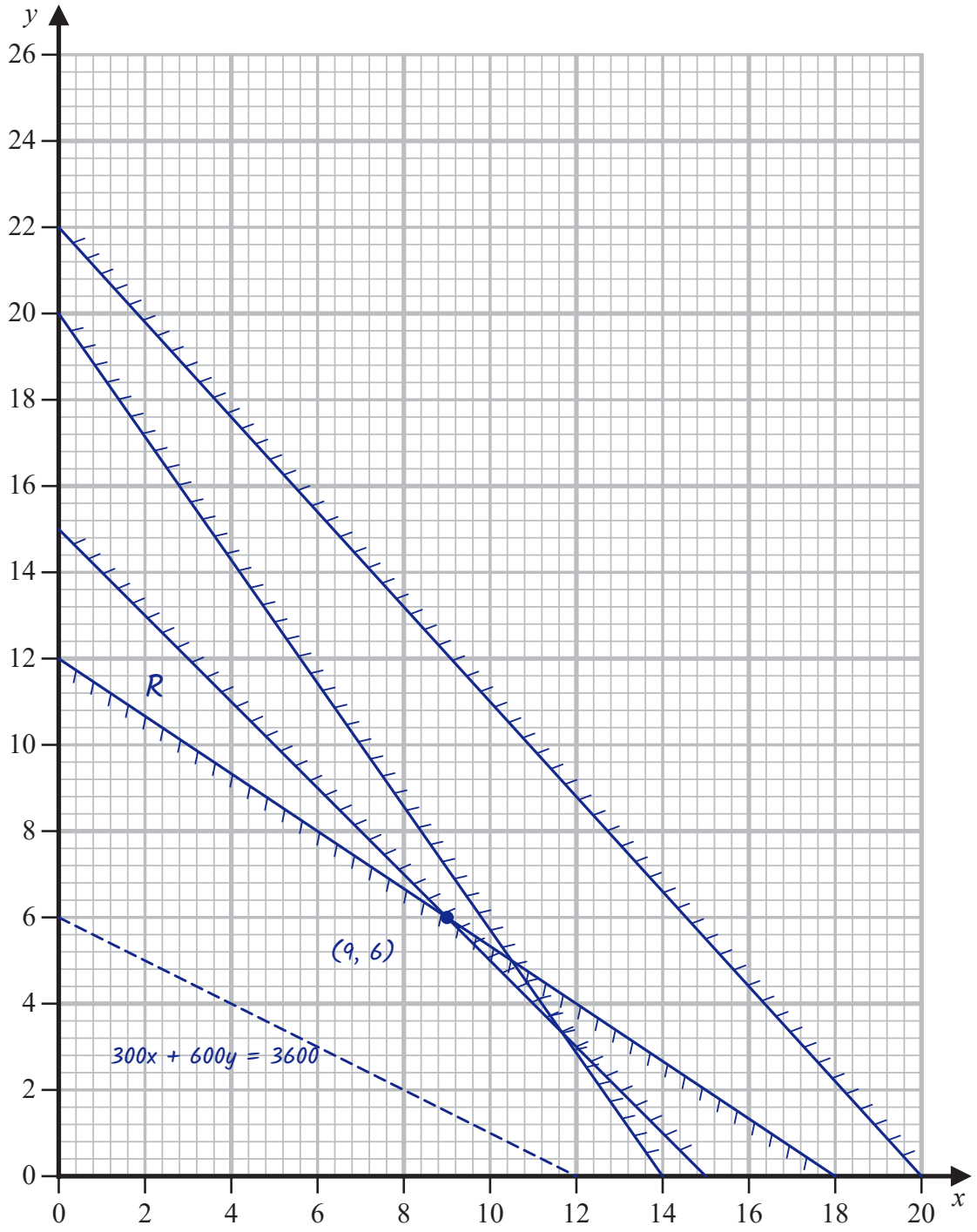


Diagram 1

Question 6 continued

(c) Lines drawn on Diagram 1: $11x + 10y = 220$,
$10x + 7y = 140$, $x + y = 15$, $2x + 3y = 36$,
with the unwanted sides shaded; feasible region labelled R.

(d) Objective line $300x + 600y = 3600$ drawn (gradient $-\frac{1}{2}$)
and moved towards the origin (minimising).
Last point of R reached: $x + y = 15$ and $2x + 3y = 36$

$2x + 3(15 - x) = 36 \Rightarrow x = 9, \quad y = 6$

$z = y \div 2 = 3$

$P = 300(9) + 600(6) = 2700 + 3600 = 6300$

Martin should make 9 carrot cakes, 6 apple cakes and
3 chocolate cakes, using 6300 g of sugar.

(e) Flour used $= 275(9) + 200(6) + 100(3) = 3975$ g

Flour left $= 5500 - 3975 = 1525$ g

Eggs used $= 5(9) + 2(6) + 3(3) = 66$

Eggs left $= 70 - 66 = 4$ eggs

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Question 6 continued

Question 6 continued

(Total for Question 6 is 17 marks)

TOTAL FOR PAPER: 75 MARKS

END

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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 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

- 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 ▶

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J:1/1/1/1/1/1/

P 6 3 1 5 4 A

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

1.

	A	B	C	D	E	F	G
A	–	43	52	47	59	53	55
B	43	–	59	45	46	52	47
C	52	59	–	51	50	55	51
D	47	45	51	–	52	49	55
E	59	46	50	52	–	57	48
F	53	52	55	49	57	–	55
G	55	47	51	55	48	55	–

The table above shows the least distances, in metres, between seven classrooms, A, B, C, D, E, F and G. A teacher needs to visit each classroom, starting and finishing at A, and wishes to minimise the total distance travelled.

(a) Show that there are two nearest neighbour routes that start from A. State these routes and their corresponding lengths.

(3)

(b) Starting by deleting A, and all of its arcs, find a lower bound for the length of the teacher's route.

(3)

(c) Use your results to write down the smallest interval which you can be confident contains the optimal length of the teacher's route.

(1)

(Total for Question 1 is 7 marks)

2.

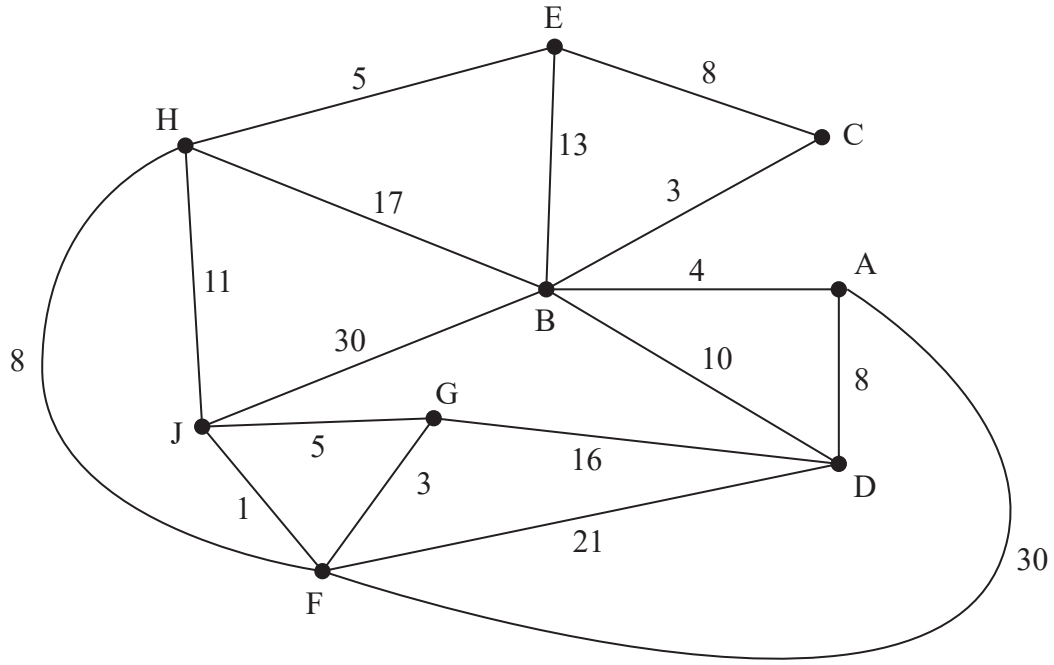


Figure 1

[*The total weight of the network is* 193]

Figure 1 represents a network of roads. The number on each edge represents the length, in miles, of the corresponding road. Jan wishes to travel from A to J. She wishes to minimise the distance she travels.

(a) Use Dijkstra's algorithm to find the shortest path from A to J. Obtain the shortest path and state its length.

(6)

On Monday, Jan needs to travel from her gym at J to her home at H via her office at A.

(b) State the shortest path from J to H via A and its length.

(2)

On Tuesday, Jan needs to check each road. She must travel along each road at least once. Jan must start and finish at A.

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

(5)

On Wednesday, Jan decides to start her inspection route at G but can finish her route at a different node. The inspection route must still traverse each road at least once.

(d) Determine where the route should finish so that the length of the inspection route is minimised. You must give reasons for your answer and state the length of the route.

(3)

(Total for Question 2 is 16 marks)

3.

1.8 1.4 2.6 1.6 2.8 0.9 3.1 0.8 1.2 2.4 0.6

(a) Use the first-fit bin packing algorithm to determine how the numbers listed above can be packed into bins of size 5

(3)

The list is to be sorted into descending order.

(b) (i) Perform one pass of a bubble sort, starting at the left-hand end of the list. You must write down the list that results at the end of the first pass.

(ii) Write down the number of comparisons and the number of swaps performed during the first pass.

(3)

After a second pass using this bubble sort, the updated list is

2.6 1.8 2.8 1.6 3.1 1.4 1.2 2.4 0.9 0.8 0.6

(c) Use a quick sort on this updated list to obtain the fully sorted list in descending order. You must make your pivots clear.

(4)

(d) Apply the first-fit decreasing bin packing algorithm to the fully sorted list to pack the numbers into bins of size 5

(3)

(Total for Question 3 is 13 marks)

4.

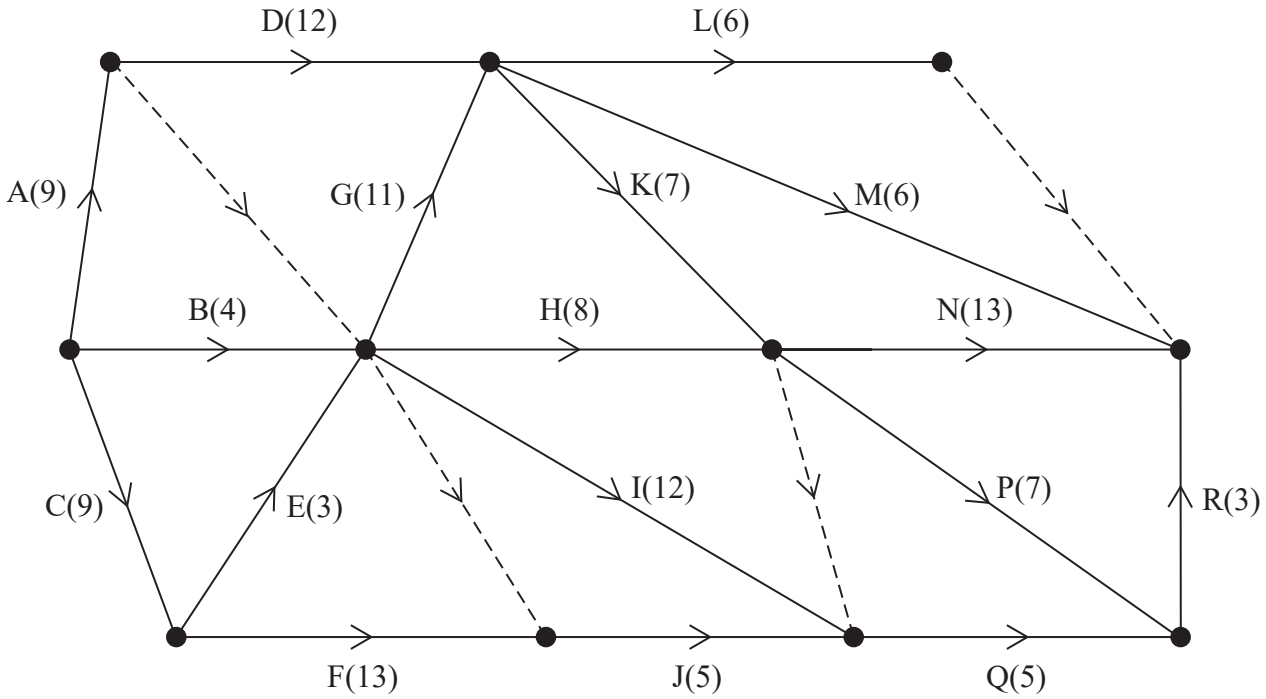


Figure 2

[*The sum of the durations of all the activities is* 133 *days*]

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 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.

(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 J. You must make the numbers you use in your calculation clear.

(1)

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

(1)

Diagram 2 in the answer book shows a partly completed scheduling diagram for this project.

(f) Complete the scheduling diagram, using the minimum number of workers, so that the project is completed in the minimum time.

(4)

(Total for Question 4 is 13 marks)

5.

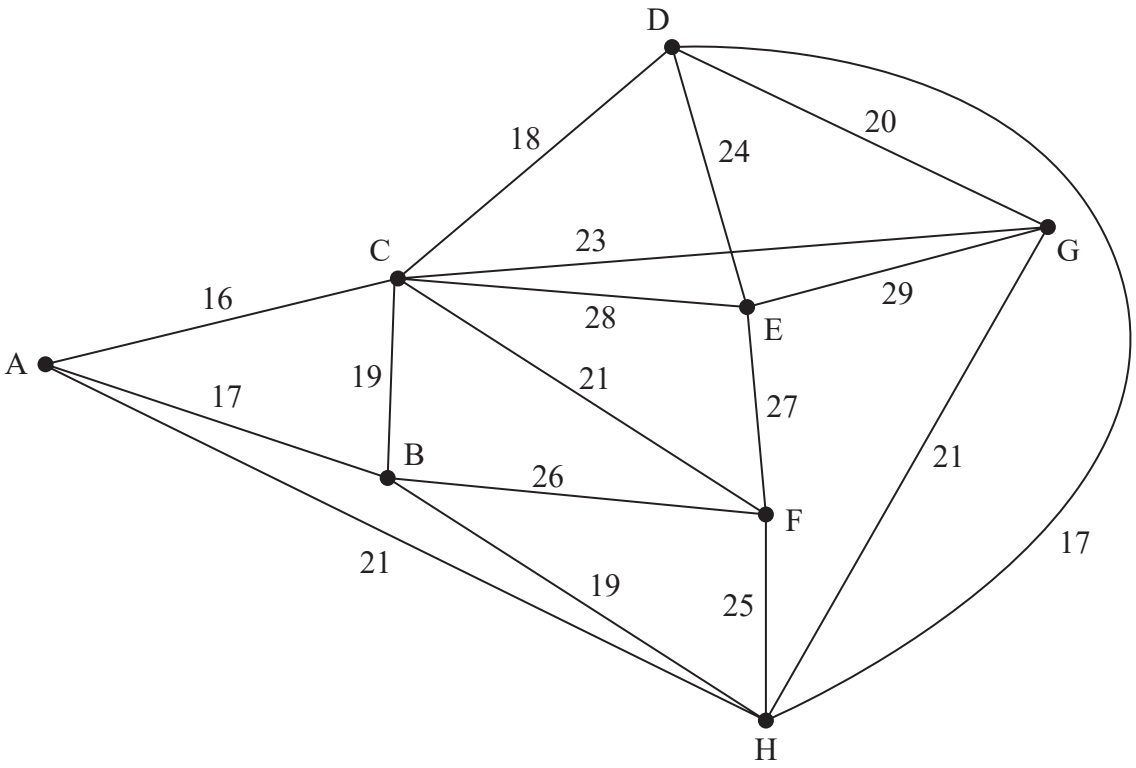


Figure 3

(a) Explain why it is impossible to draw a graph with eight vertices in which the vertex orders are 1, 2, 2, 3, 3, 4, 4 and 6

(1)

Figure 3 shows the network T. The numbers on the arcs represent the distances, in km, between the eight vertices, A, B, C, D, E, F, G and H.

(b) Determine whether or not A – C – D – E – C – B – F is an example of a path on T. You must justify your answer.

(2)

(c) Use Prim's algorithm, starting at A, to find the minimum spanning tree for T. You must clearly state the order in which you select the arcs of the tree.

(3)

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

(1)

The weight of arc CF is now increased to a value of x. The minimum spanning tree for T is unique and includes the same arcs as those found in (c).

(e) Write down the smallest interval that must contain x.

(2)

(Total for Question 5 is 9 marks)

6. Martin is making three types of cake for a picnic. The three types of cake are carrot cake, apple cake and chocolate cake. Along with other ingredients,

- each carrot cake contains 275 grams of flour, 300 grams of sugar and 5 eggs
- each apple cake contains 200 grams of flour, 400 grams of sugar and 2 eggs
- each chocolate cake contains 100 grams of flour, 400 grams of sugar and 3 eggs

If Martin makes only one type of cake then he has enough time to prepare 15 carrot cakes or 20 apple cakes or 30 chocolate cakes.

Martin has 5.5 kilograms of flour and 70 eggs available and he has promised the picnic organisers that he will make at least 18 cakes in total.

Martin plans to make a selection of these cakes and wants to minimise the total amount of sugar that he uses.

Let x be the number of carrot cakes made, y the number of apple cakes made and z the number of chocolate cakes made.

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

(6)

A further constraint is that $y = 2z$

(b) Explain what this constraint means in the context of the question.

(1)

The constraint $y = 2z$ reduces the problem to the following

Minimise $P = 300x + 600y$

subject to $11x + 10y \leqslant 220$

$10x + 7y \leqslant 140$

$x + y \leqslant 15$

$2x + 3y \geqslant 36$

$x \geqslant 0,\ y \geqslant 0$

(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 number of each type of cake that Martin should make, and the amount of sugar used.

(4)

(e) Determine how much flour and how many eggs Martin will have left over after making the optimal number of cakes.

(2)

(Total for Question 6 is 17 marks)

TOTAL FOR PAPER: 75 MARKS

END

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