Pearson Edexcel Level 3 GCE

Friday 17 May 2024

Afternoon

Paper reference **8FM0/27**

Further Mathematics

Advanced Subsidiary
Further Mathematics options
27: Decision Mathematics 1
(Part of options D, F, H and K)

You must have:
Mathematical Formulae and Statistical Tables (Green), calculator,
D1 Answer Book (enclosed)

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).
- **Fill in the boxes** at 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 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.
- Inexact answers should be given to three significant figures unless otherwise stated.
- Do not return the question paper with the D1 Answer Book.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- The total mark for this part of the examination is 40. There are 4 questions.
- 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.

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1.

4 6.5 7 1.3 2 5 1.5 6 4.5 6 1

The list of eleven numbers shown above is to be sorted into **descending** order.

(a) Carry out a **quick sort** to produce the sorted list. You should show the result of each pass and identify the pivots clearly.

(3)

(b) Use the **first-fit decreasing** bin packing algorithm to pack the numbers into bins of size 10

(3)

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

(2)

A **different** list of eleven numbers is to be sorted into **descending** order using a **bubble sort**. The list after the **second** pass is

4.5 5.6 3.8 6.7 5.4 1.6 4.8 9.1 3.3 1.7 1.5

(d) Explain how you know that at least one of the first two passes of the bubble sort was **not** carried out correctly.

(1)

(Total for Question 1 is 9 marks)

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2. A company manages an awards evening.

The table below lists the activities required to set up the room for the evening, and their immediately preceding activities. Each activity requires exactly one person.

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

Figure 1 shows a partially completed activity network used to model the project. Each activity is represented by an arc.

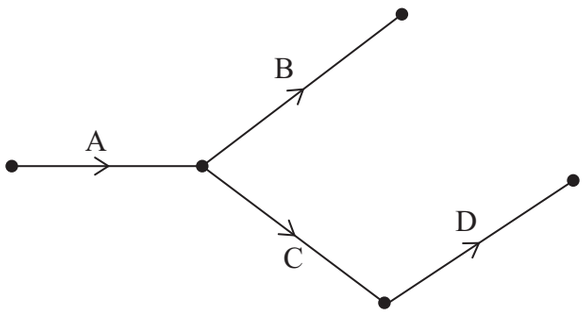


Figure 1

(a) Add the remaining five activities to Diagram 1 in the answer book to complete the activity network, using exactly two dummies.

(3)

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In addition to setting up the room, the company must prepare the meals for the guests. Figure 2 shows the activity network for preparing the main courses. The numbers in brackets represent the time, in minutes, to complete each task.

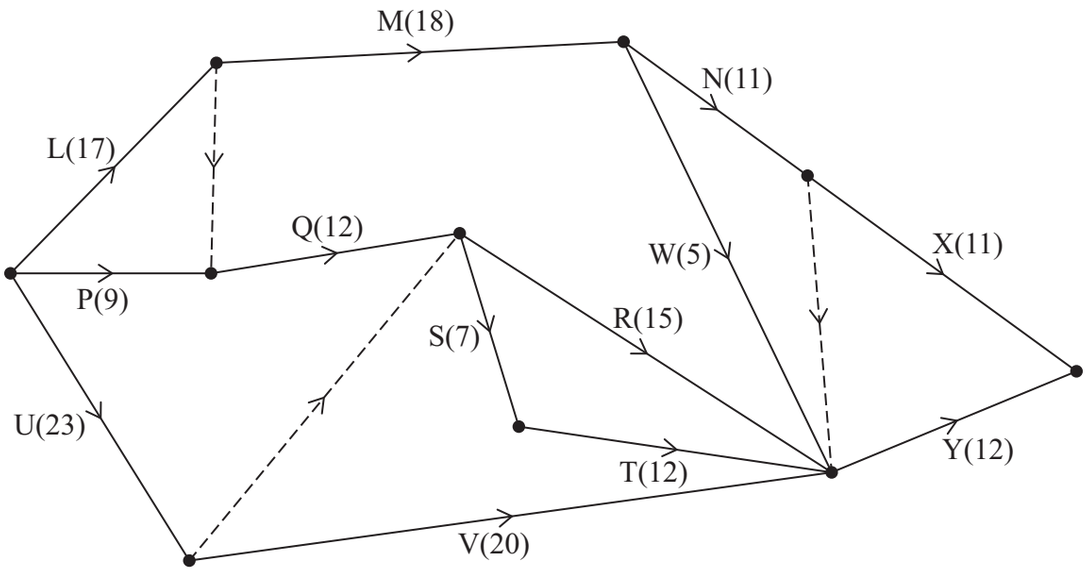


Figure 2

(b) Complete Diagram 2 in the answer book to show the early event times and the late event times for the activity network shown in Figure 2.

(3)

(c) State the critical activities.

(1)

(d) Given that the main courses need to be ready to be served (with all activities completed) at 8 pm, state the latest time that activity R can start.

(1)

(Total for Question 2 is 8 marks)



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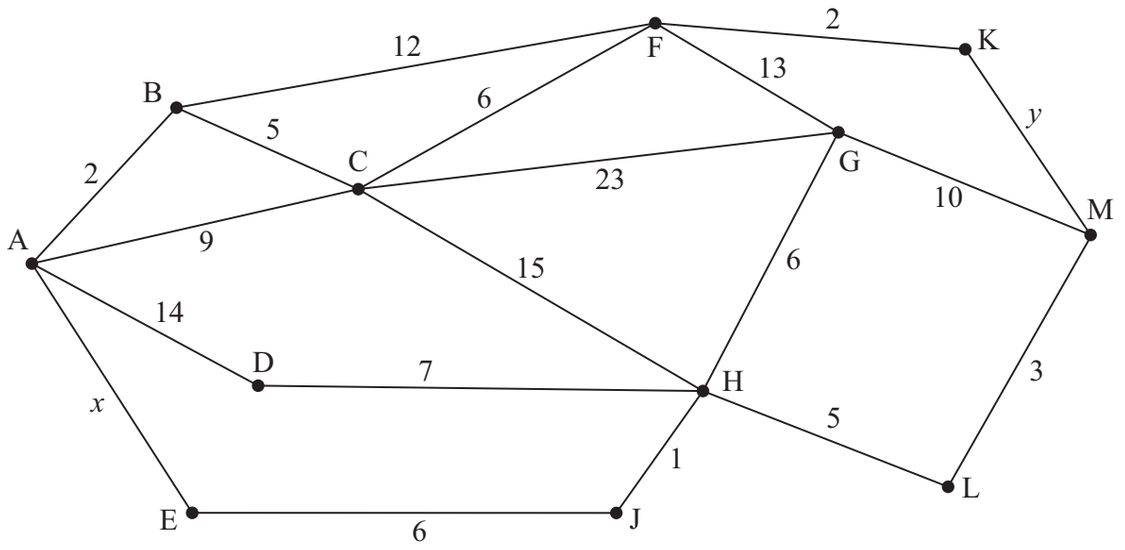


Figure 3

[*The total weight of the network is* $139 + x + y$]

(a) Explain what is meant by the term "tree".

(1)

Figure 3 represents a network of walkways in a warehouse.
The arcs represent the walkways and the nodes represent junctions between them.
The number on each arc represents the length, in metres, of the corresponding walkway.

The values x and y are unknown, however it is known that x and y are integers and that

$$9 < x < y < 14$$

(b) (i) Use Dijkstra's algorithm to find the shortest route from A to M.

(ii) State an expression for the length of the shortest route from A to M.

(6)

The warehouse manager wants to check that all of the walkways are in good condition.

Their inspection route starts at B and finishes at C.

The inspection route must traverse each walkway at least once and be as short as possible.

(c) State the arcs that are traversed twice.

(1)

(d) State the number of times that H appears in the inspection route.

(1)

The warehouse manager finds that the total length of the inspection route is 172 metres.

(e) Determine the value of x and the value of y

(2)

(Total for Question 3 is 11 marks)

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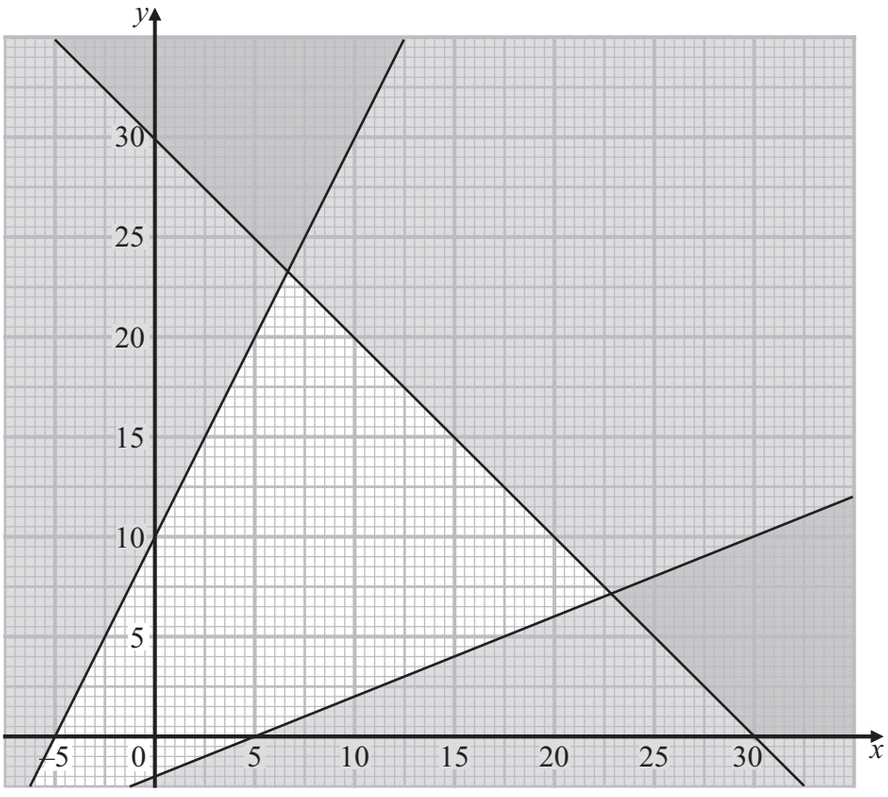


Figure 4

Figure 4 shows three of the six constraints for a linear programming problem in x and y

The unshaded region and its boundaries satisfy these three constraints.

(a) State these three constraints as simplified inequalities with integer coefficients.

(3)

The variables x and y represent the number of orange fish and the number of blue fish, respectively, that are to be kept in an aquarium.

The number of fish in the aquarium is subject to these three further constraints

- there must be at least one blue fish
- the orange fish must not outnumber the blue fish by more than ten
- there must be no more than five blue fish for every orange fish

(b) Write each of these three constraints as a simplified inequality with integer coefficients.

(2)

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(c) Represent these three constraints by adding lines and shading to Diagram 1 in the answer book, labelling the feasible region, R

(3)

The total value (in pounds) of the fish in the aquarium is given by the objective function

$$\text{Maximise } P = 3x + 5y$$

(d) (i) Use the objective line method to determine the optimal point of the feasible region, giving its coordinates as exact fractions.

(ii) Hence find the maximum total value of the fish in the aquarium, stating the optimal number of orange fish and the optimal number of blue fish.

(4)

(Total for Question 4 is 12 marks)

TOTAL FOR DECISION MATHEMATICS 1 IS 40 MARKS

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Please check the examination details below before entering your candidate information

Candidate surname StemUp Model Solution | Other names

Centre Number | Candidate Number

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Total Marks

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1.

4 6.5 7 1.3 2 5 1.5 6 4.5 6 1

(a) Quick sort (middle right pivots, ringed):

4	6.5	7	1.3	2	(5)	1.5	6	4.5	6	1	pivot 5
6.5	7	(6)	6	5	4	1.3	2	(1.5)	4.5	1	pivots 6, 1.5
6.5	(7)	6	6	5	4	(2)	4.5	1.5	1.3	(1)	pivots 7, 2, 1
7	6.5	6	6	5	4	(4.5)	2	1.5	1.3	1	pivot 4.5
7	6.5	6	6	5	4.5	4	2	1.5	1.3	1	sorted

Sorted list: 7 6.5 6 6 5 4.5 4 2 1.5 1.3 1

(b) First-fit decreasing, using the sorted list:

Bin 1: 7 2 1

Bin 2: 6.5 1.5 1.3

Bin 3: 6 4

Bin 4: 6

Bin 5: 5 4.5

(c) Total = 4 + 6.5 + 7 + 1.3 + 2 + 5 + 1.5 + 6 + 4.5 + 6 + 1 = 44.8

Lower bound = 44.8 ÷ 10 = 4.48, so the minimum number of bins is 5

Part (b) uses 5 bins, so yes, it uses the minimum number of bins.

(d) In a descending bubble sort, after two passes the two smallest values must be in the last two positions (10th and 11th). The second smallest value, 1.6, is in 6th position (not 10th), so at least one of the first two passes was not carried out correctly.

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Question 1 continued

(Total for Question 1 is 9 marks)

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2.

(a)

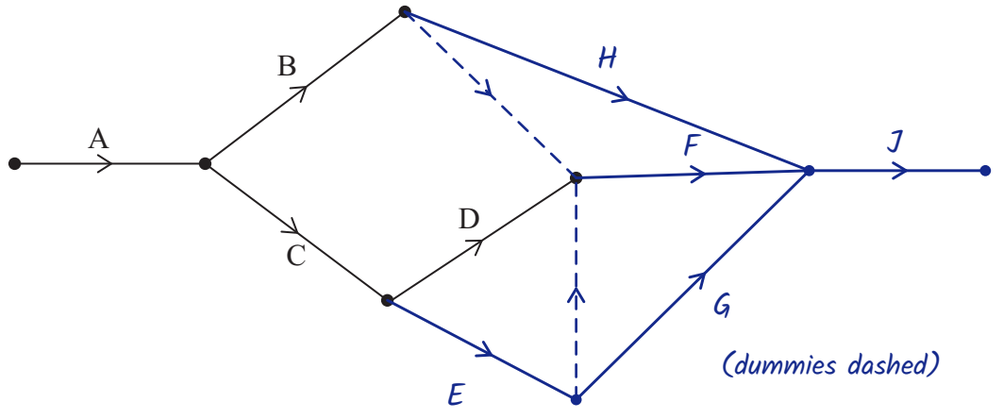
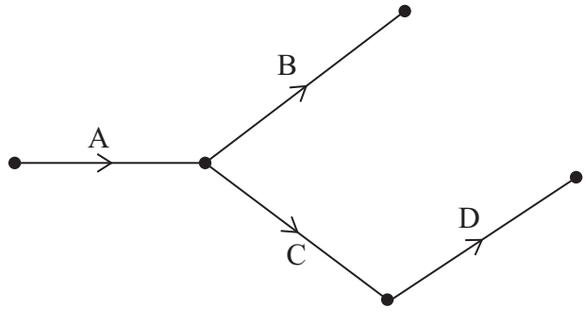


Diagram 1

Use this diagram only if you need to redraw your activity network.



Copy of Diagram 1

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Question 2 continued

(b)

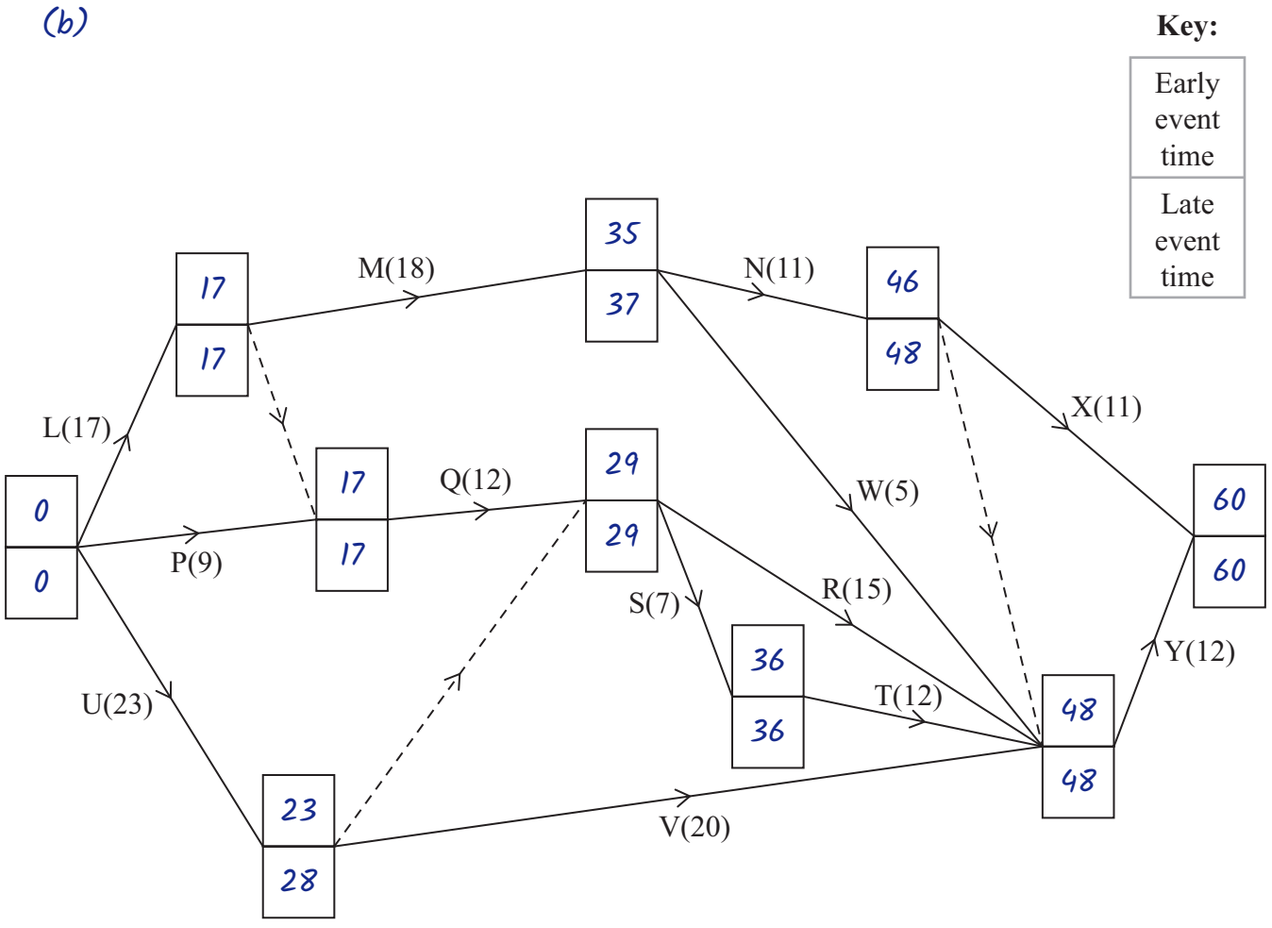


Diagram 2

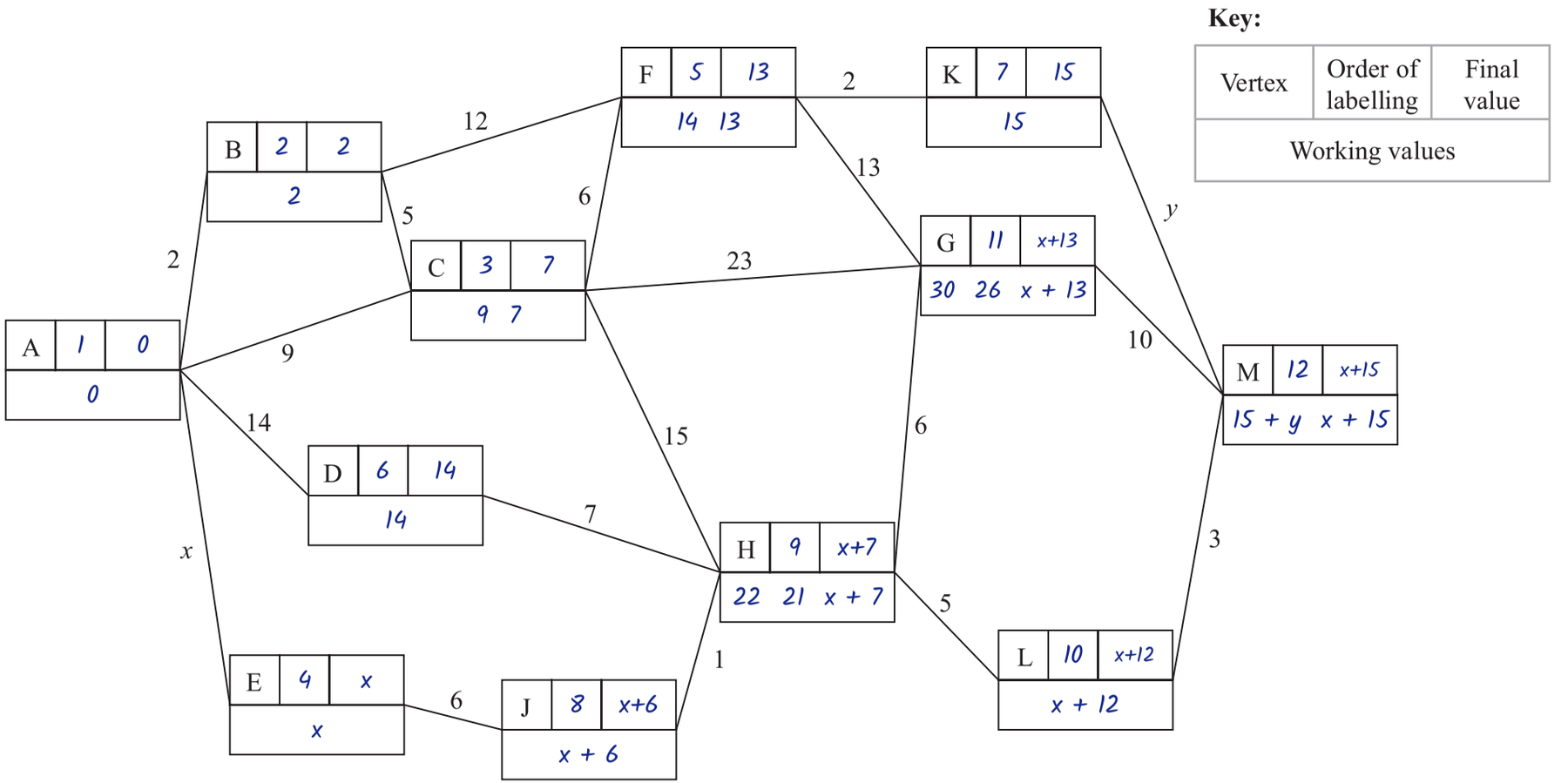
(c) Critical activities: L, Q, S, T and Y

(d) Minimum completion time = 60 minutes, so start at 7:00 pm at the latest.
Latest start of R = 48 − 15 = 33 minutes after 7:00 pm
Latest time R can start: 7:33 pm

(Total for Question 2 is 8 marks)

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3.



Shortest route from A to M: A E J H L M

Length of shortest route from A to M: x + 15 (metres)

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Question 3 continued

(a) A tree is a connected graph with no cycles.

(b) Dijkstra working shown on the diagram on page 6.

Shortest route A E J H L M, length x + 15

(c) Orders: B = 3, C = 5, H = 5, M = 3 (all other vertices even)

The route starts at B and finishes at C, so only H and M are paired.

Shortest H to M: H L M = 5 + 3 = 8 (H G M = 6 + 10 = 16)

Arcs traversed twice: HL and LM

(d) Order of H = 5, plus 1 for repeating HL = 6

H appears 6 ÷ 2 = 3 times

(e) 139 + x + y + 8 = 172

x + y = 25

x, y integers with $9 < x < y < 14 \Rightarrow y = 13$ and x = 12

x = 12, y = 13

(Total for Question 3 is 11 marks)

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4.

(a) $x + y \leq 30$

$y \leq 2x + 10$

$5y \geq 2x - 10$

(b) $y \geq 1$

$x \leq y + 10$

$y \leq 5x$

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Question 4 continued

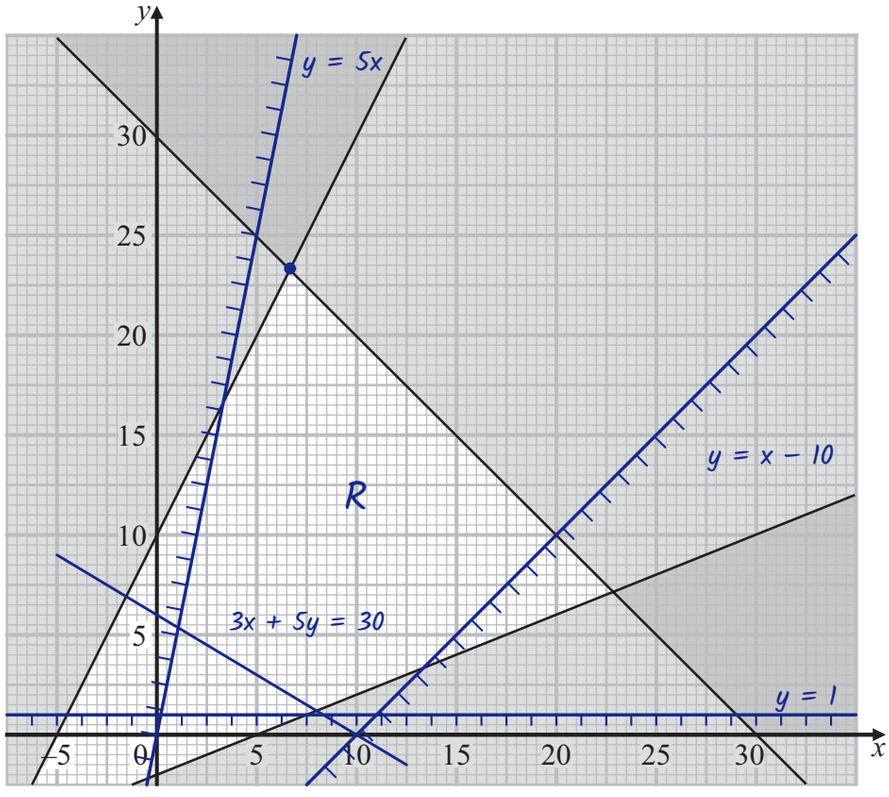


Diagram 1

There is a copy of Diagram 1 on page 11 if you need to redraw your graph.

(c) Lines $y = 1$, $y = x - 10$ and $y = 5x$ drawn; rejected sides hatched; feasible region R labelled. Objective line $3x + 5y = 30$ drawn (for (d)).

Question 4 continued

(d)(i) Objective line $3x + 5y = 30$ drawn on Diagram 1 (gradient $-3/5$).

Moving it parallel, away from the origin, the last point of R it reaches is the intersection of $x + y = 30$ and $y = 2x + 10$:

$x + (2x + 10) = 30 \Rightarrow 3x = 20 \Rightarrow x = 20/3,\ y = 30 - 20/3 = 70/3$

Optimal point $\left(\frac{20}{3}, \frac{70}{3}\right)$

(ii) Optimal vertex $\approx (6.67, 23.33)$; test integer points nearby:

$(6, 23)$: $y \leq 2x + 10 \Rightarrow 23 \leq 22$ ✗ (not feasible)

$(6, 24)$: $24 \leq 22$ ✗ (not feasible)

$(7, 24)$: $x + y = 31 > 30$ ✗ (not feasible)

$(7, 23)$: $x + y = 30$ ✓, $23 \leq 24$ ✓, $P = 3(7) + 5(23) = 21 + 115 = 136$

(on $x + y = 30$, $P = 150 - 2x$ and $x \geq 7$ there, so $P \leq 136$)

Maximum total value £136, with 7 orange fish and 23 blue fish.

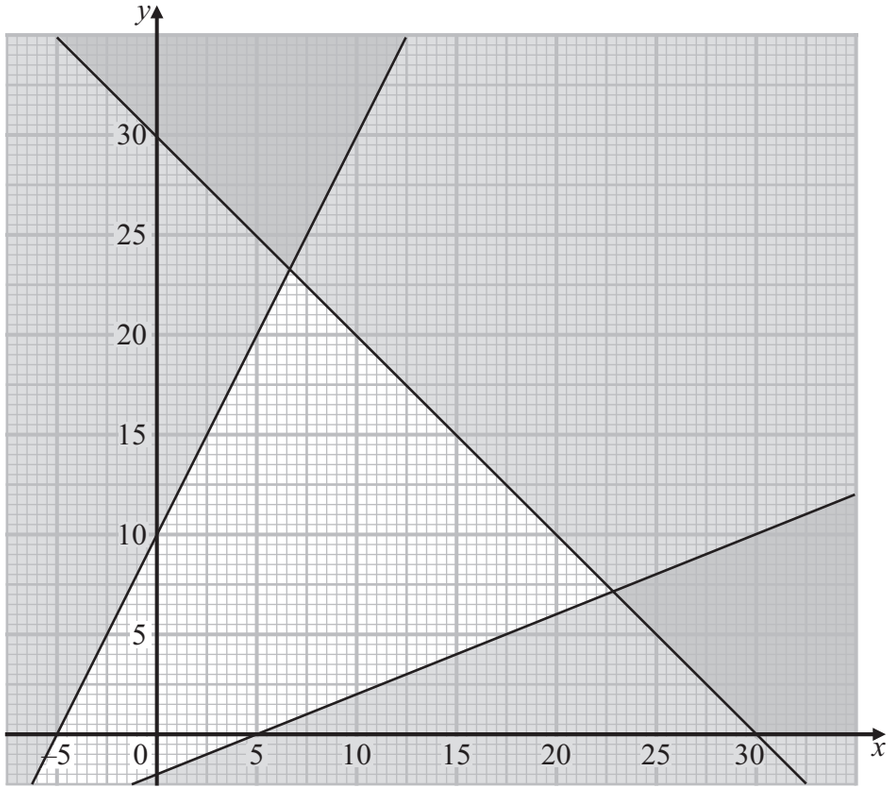
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Question 4 continued

Use this diagram only if you need to redraw your graph.



Copy of Diagram 1

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Question 4 continued

(Total for Question 4 is 12 marks)

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