5.

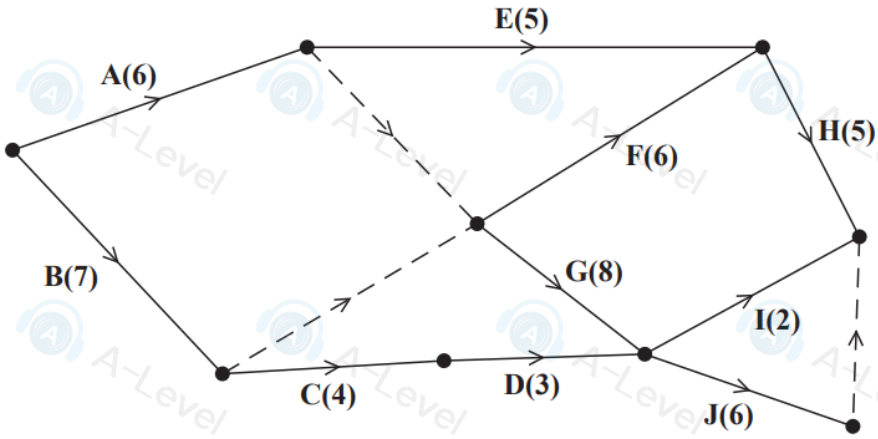


Figure 6

A project is modelled by the activity network shown in Figure 6. The activities are represented by the arcs. The number in brackets on each arc gives the time, in hours, to complete the corresponding 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 late event times.

(3)

(c) State the minimum project completion time and list the critical activities.

(2)

(d) Calculate the maximum number of hours by which activity E could be delayed without affecting the shortest possible completion time of the project. You must make the numbers used 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)

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

(f) Schedule the activities using Grid 1 in the answer book.

(3)

Before the project begins it becomes apparent that activity E will require an additional 6 hours to complete. The project is still to be completed in the shortest possible time and the time to complete all other activities is unchanged.

(g) State the new minimum project completion time and list the new critical activities.

(2)

(Total 14 marks)

Leave blank

5.

Activity	Immediately preceding activities
A	
B	
C	
D	
E	

Activity	Immediately preceding activities
F	
G	
H	
I	
J	

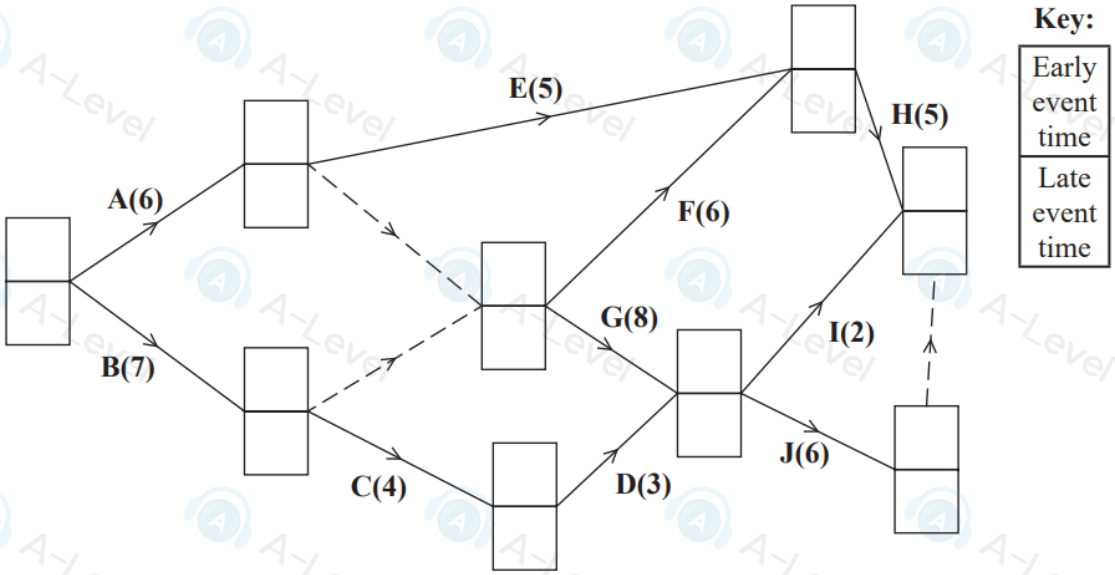


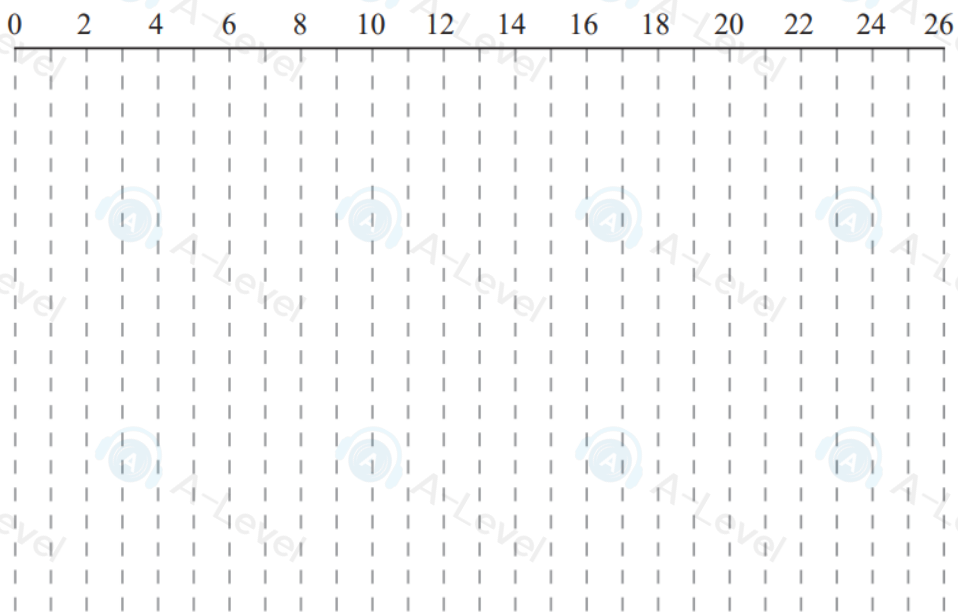
Diagram 1

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 5 continued



Grid 1

Q5

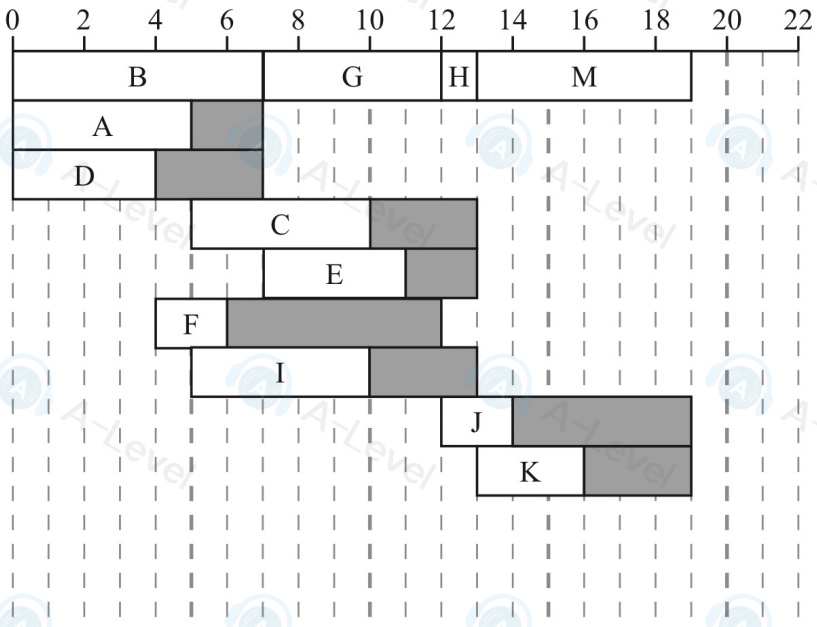
(Total 14 marks)

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)

6.

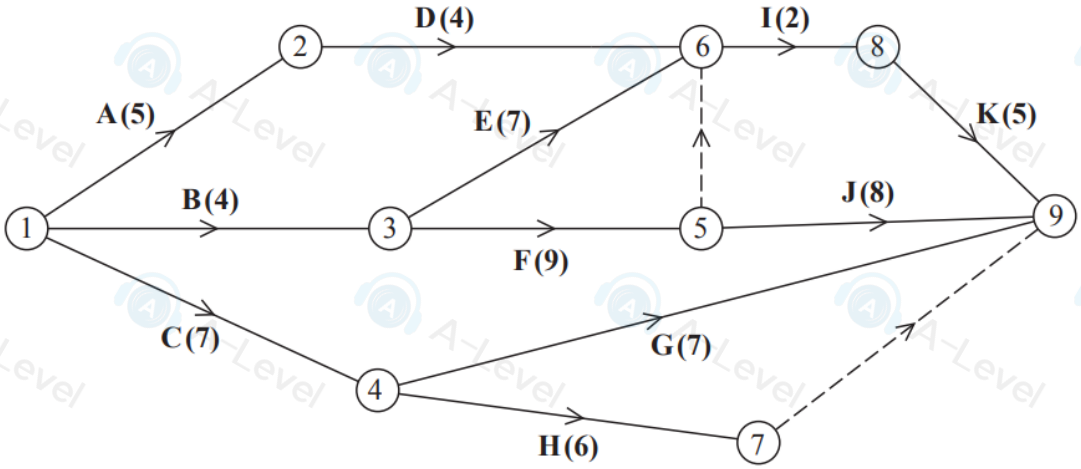


Figure 4

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 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 5 to event 6

(ii) from event 7 to event 9

(2)

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

(4)

(c) State the minimum project completion time.

(1)

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

(2)

(e) On Grid 1 in your answer book, draw a cascade (Gantt) chart for this project.

(4)

(f) On Grid 2 in your answer book, construct a scheduling diagram to show that this project can be completed with three workers in just one more hour than the minimum project completion time.

(3)

(Total 16 marks)

TOTAL FOR PAPER: 75 MARKS

END

Leave blank

6. (a)

(b)

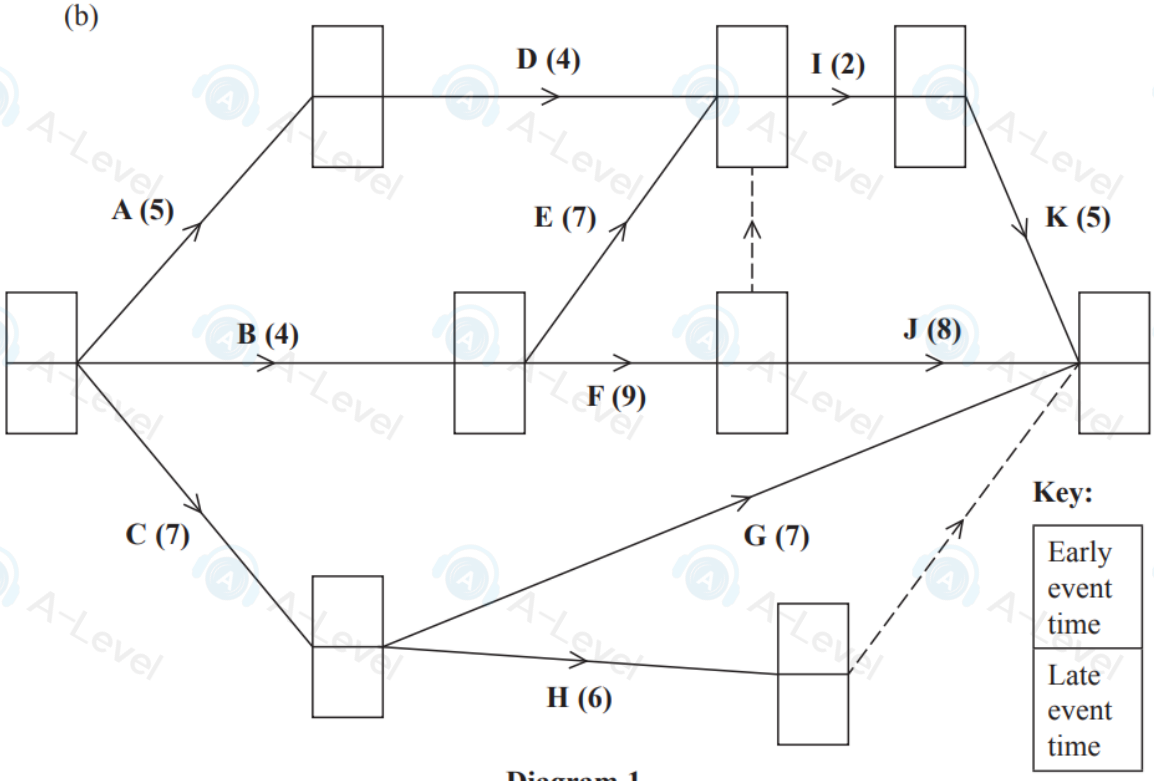


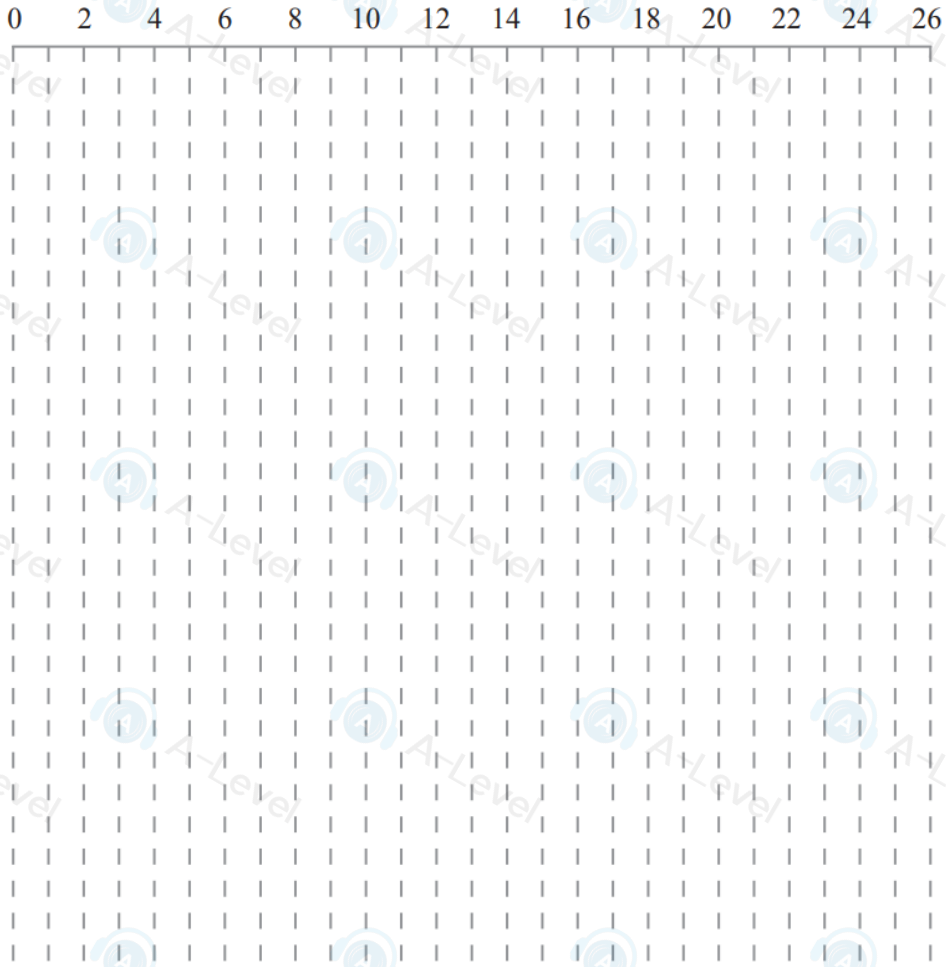
Diagram 1

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

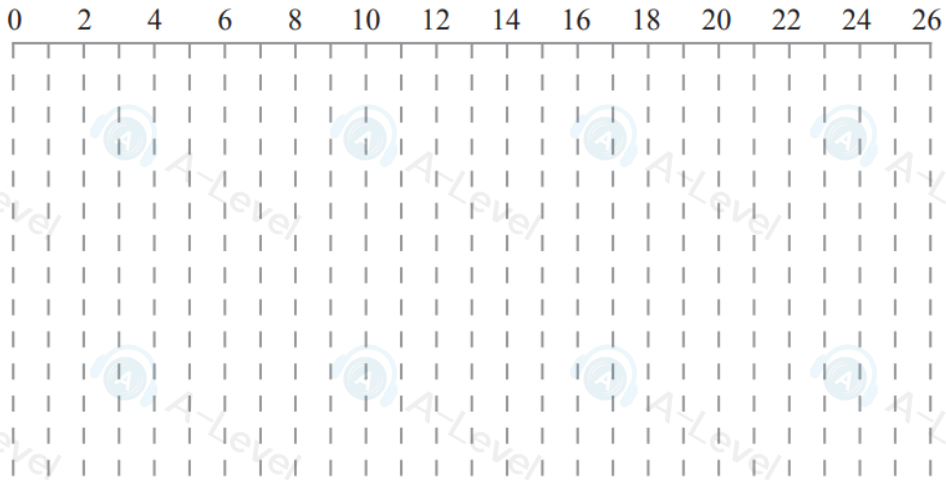
Question 6 continued

(e)



Grid 1

(f)



Grid 2

Q6

(Total 16 marks)

TOTAL FOR PAPER: 75 MARKS

END

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

7:

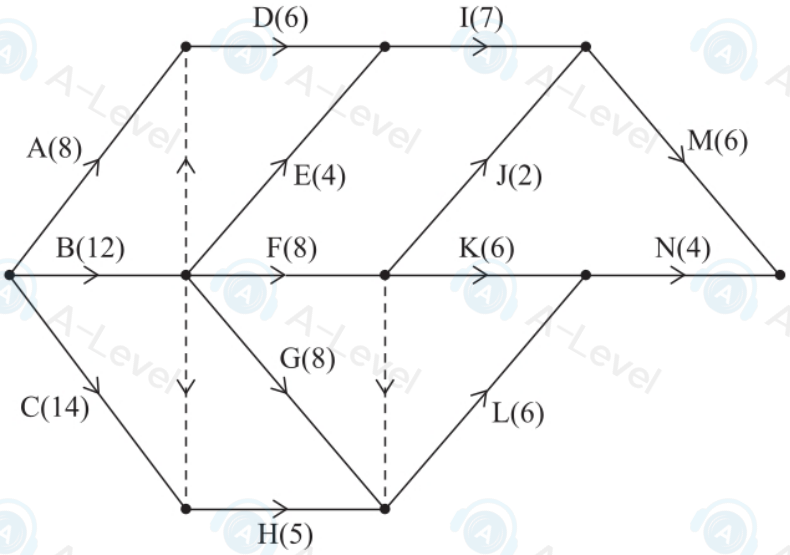


Figure 3

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

(a) Complete the precedence table in the answer book to show the immediately preceding activities for the project.

(3)

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

(4)

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

(2)

(d) Draw a Gantt (cascade) chart on the grid in the answer book.

(4)

(e) Use the Gantt chart to determine the minimum number of workers required to complete the project in the minimum time. You must make specific reference to the number of workers, activities and times.

(3)

(Total for Question 7 is 16 marks)

2.

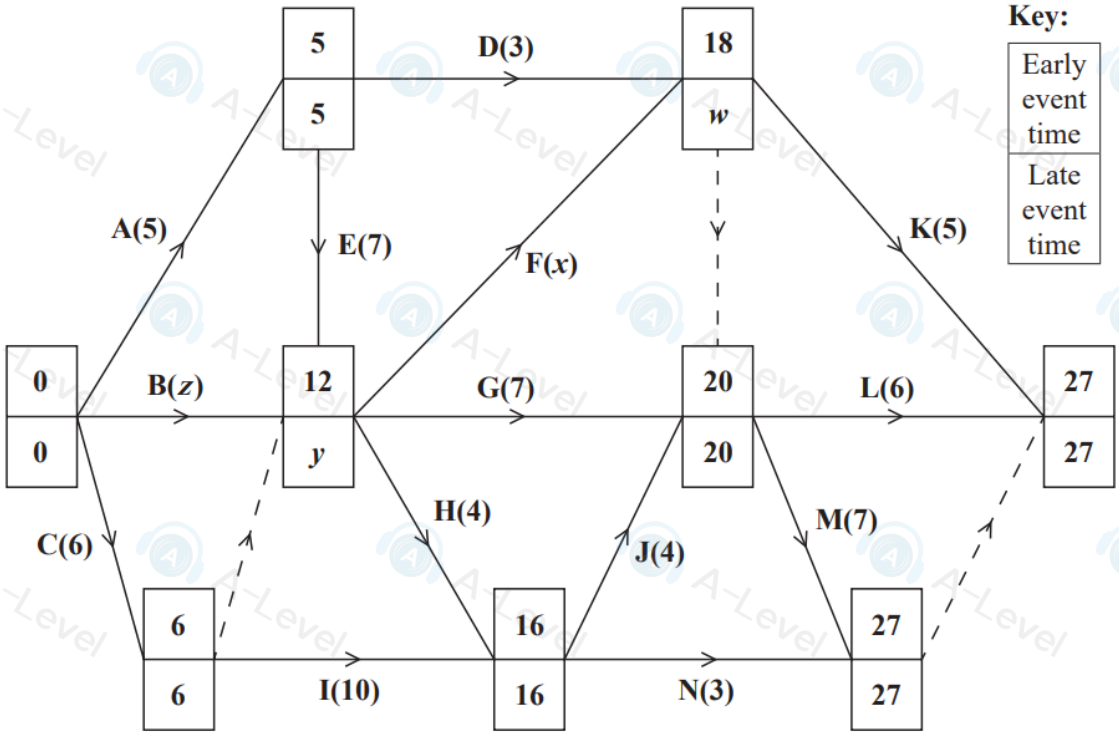


Figure 3

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 and the duration of the activity, in days, is shown in brackets. Each activity requires exactly one worker. The early event times and late event times are shown at each vertex.

Given that the total float on activity B is 2 days and the total float on activity F is also 2 days,

(a) find the values of w, x, y and z.

(4)

(b) Draw a cascade (Gantt) 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)

Leave blank

2.

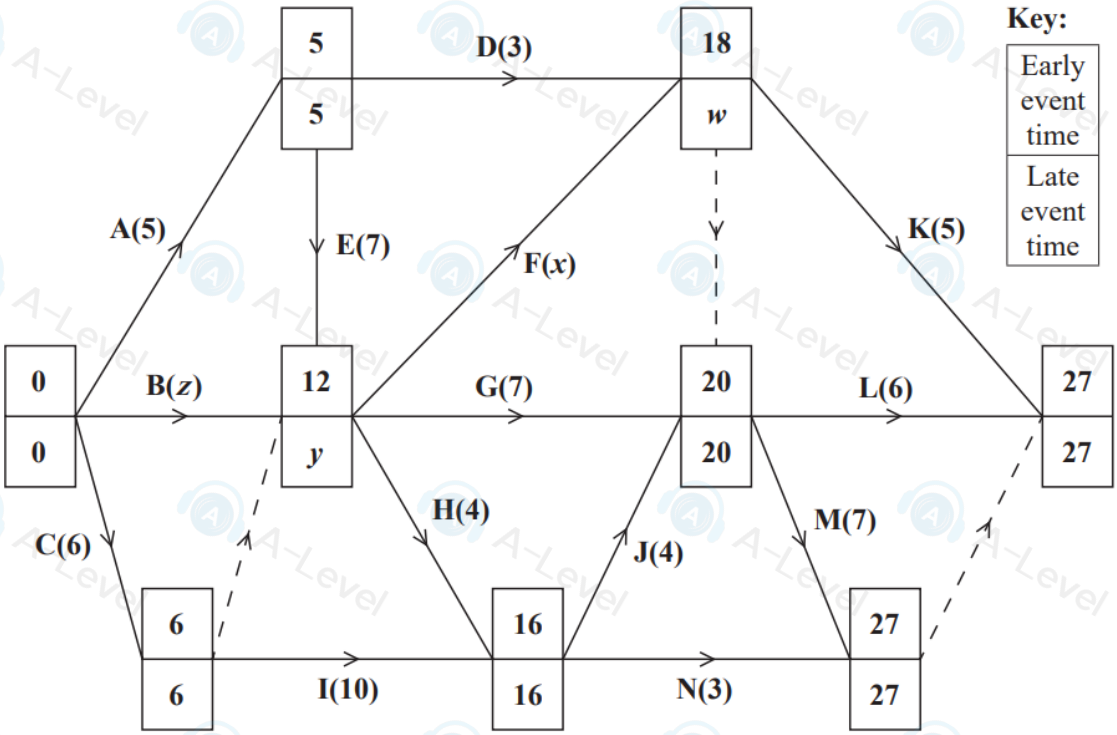


Figure 3

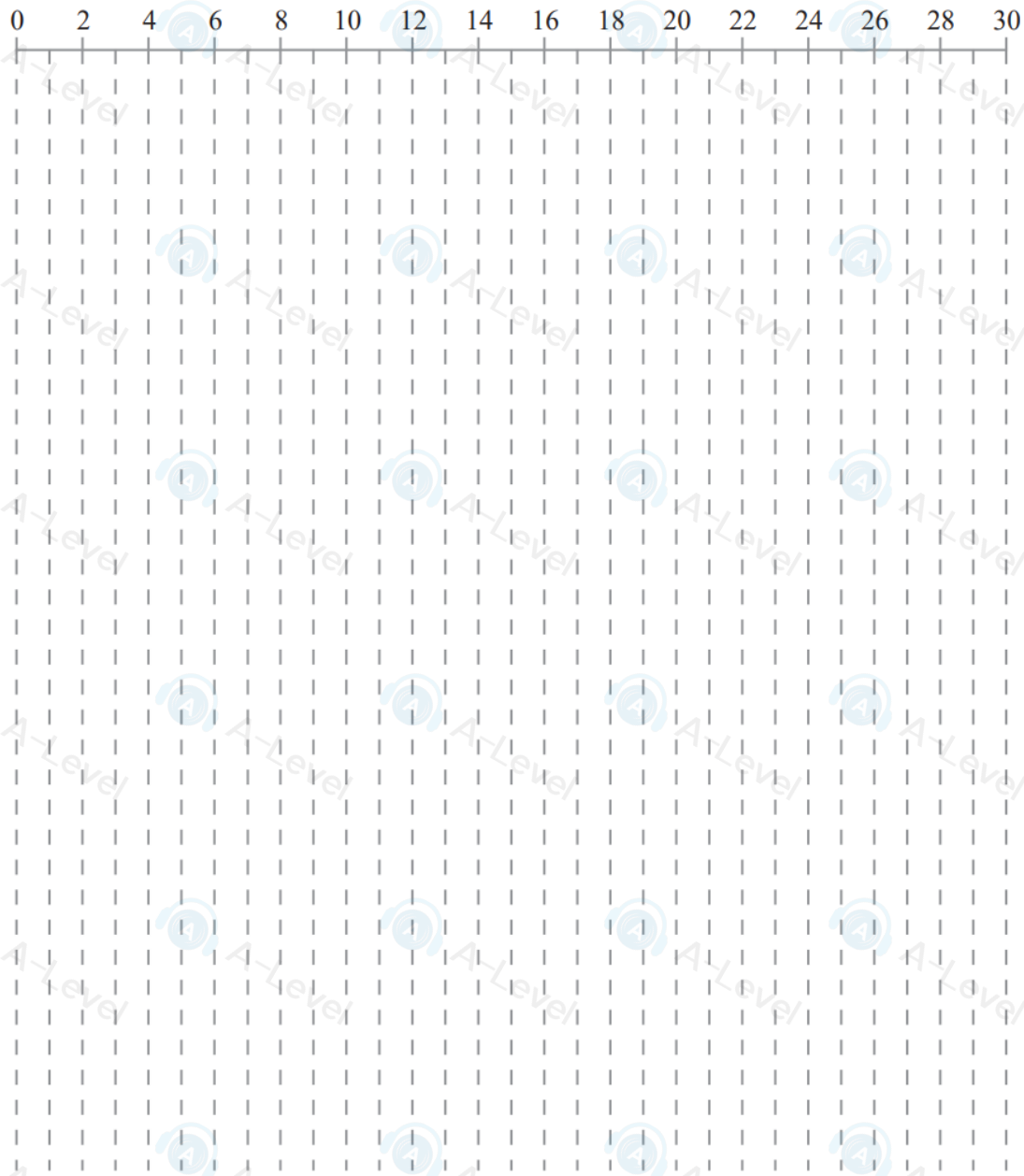
$w =$ _____ $x =$ _____ $y =$ _____ $z =$ _____

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 2 continued



Grid 1

Q2

(Total 10 marks)

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

1.

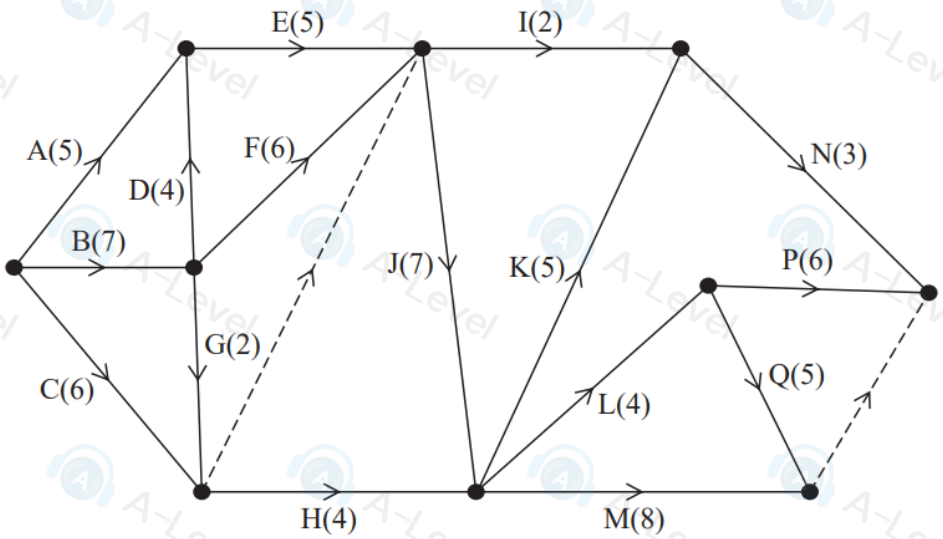


Figure 1

A project is modelled by the activity network shown in Figure 1. 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 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) Calculate the maximum number of days by which activity H could be delayed without lengthening the completion time of the project. You must make the numbers used in your calculation clear.

(1)

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

(2)

(d) Schedule the activities on Grid 1 in the answer book, using the minimum number of workers, so that the project is completed in the minimum time.

(3)

(Total for Question 1 is 10 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

8. 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:

$$x \geqslant 2$$
$$-x + 24y \geqslant 24$$
$$7x + 8y \leqslant 112$$

(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)

TOTAL FOR PAPER: 75 MARKS

END

Leave blank

8.

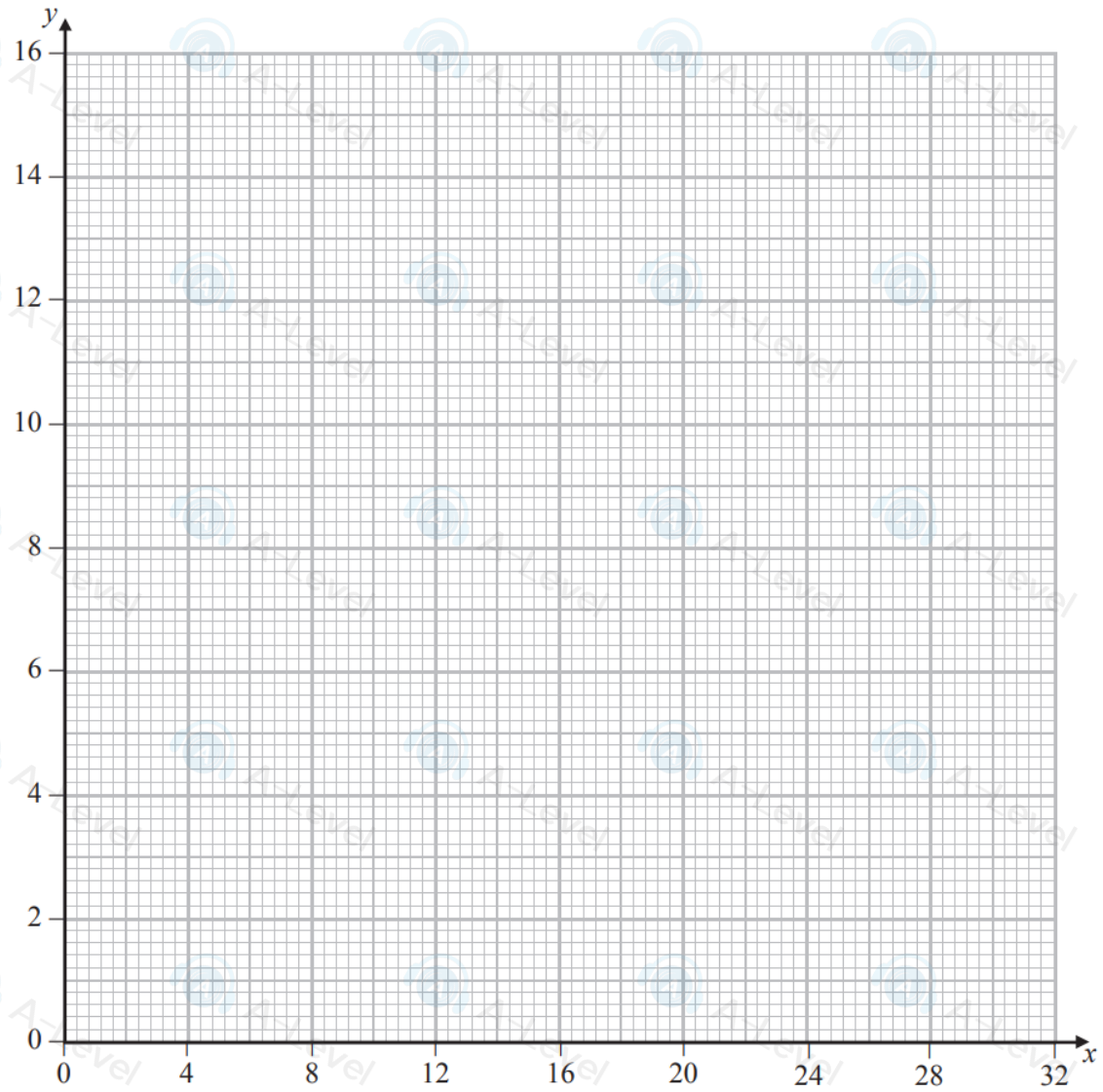


Diagram 1

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 8 continued

4.

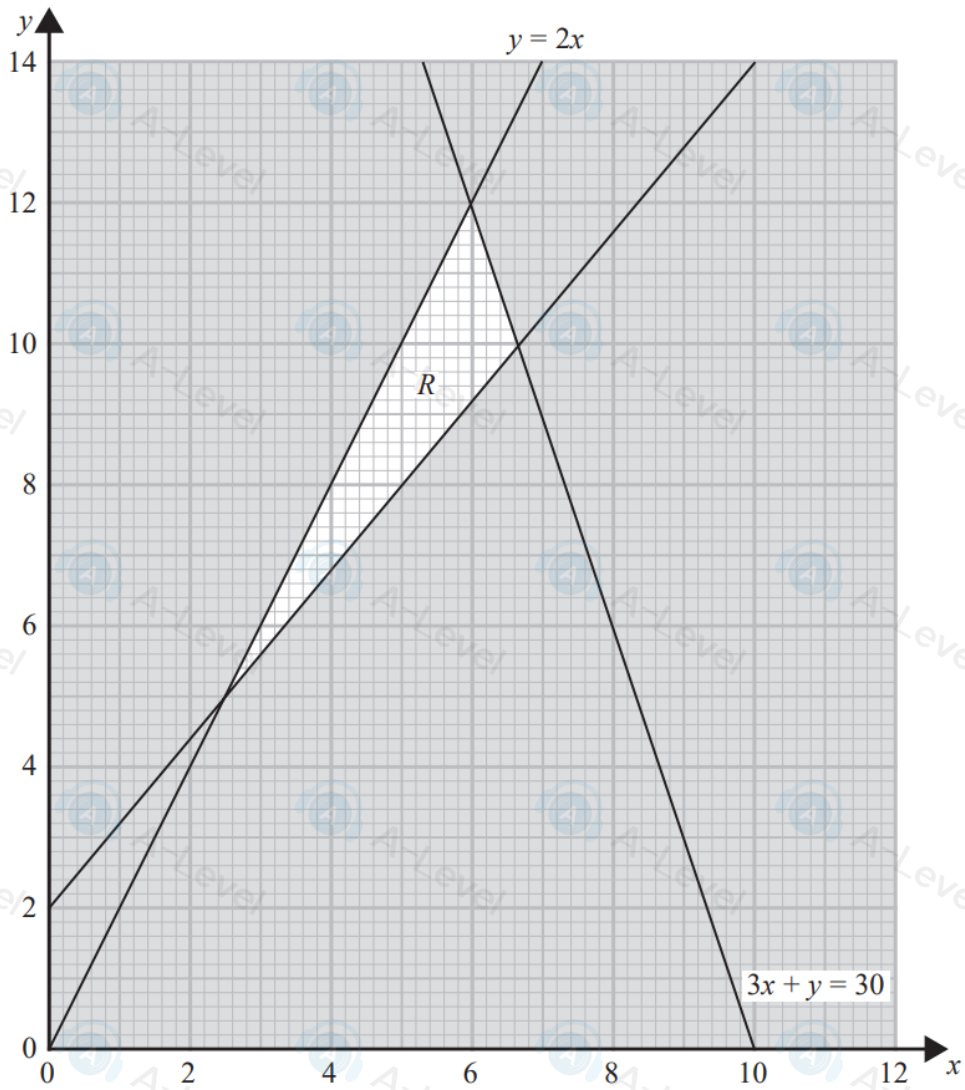


Figure 2

Figure 2 shows the constraints of a linear programming problem in x and y, where R is the feasible region. The equations of two of the lines are shown on the graph.

(a) Determine the inequalities that define the feasible region.

(3)

(b) Find the exact coordinates of the vertices of the feasible region.

(3)

The objective is to maximise P, where $P = 2x + ky$

(c) For the case $k = 3$, use the point testing method to find the optimal vertex of the feasible region and state the corresponding value of P.

(3)

(d) Determine the range of values for k for which the optimal vertex found in (c) is still optimal.

(2)

(Total for Question 4 is 11 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)

7. Emily is planning to sell three types of milkshake, strawberry, vanilla and chocolate.

Emily has completed some market research and has used this to form the following constraints on the number of milkshakes that she will sell each week.

- She will sell fewer than 200 non-vanilla milkshakes in total.
- She will sell at most 2.5 times as many strawberry milkshakes as vanilla milkshakes.
- At most, 75% of the milkshakes that she will sell will be vanilla.

The profit on each strawberry milkshake sold is £0.75, the profit on each vanilla milkshake sold is £1.20 and the profit on each chocolate milkshake sold is £1.45

Emily wants to maximise her profit.

Let x represent the number of strawberry milkshakes sold, let y represent the number of vanilla milkshakes sold and let z represent the number of chocolate milkshakes sold.

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

(6)

In week 1, Emily sells 100 strawberry milkshakes and 25 chocolate milkshakes.

(b) Calculate the maximum possible profit and minimum possible profit, in pounds, for the sale of all milkshakes in week 1. You must show your working.

(3)

(Total 9 marks)

Leave blank

7.

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 7 continued

Q7

(Total 9 marks)