



Rewarding Learning

General Certificate of Secondary Education
2023

Centre Number

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Candidate Number

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Further Mathematics

Unit 4 (With calculator)

Discrete and
Decision Mathematics



MV18

[GFM41]

MONDAY 26 JUNE, AFTERNOON

Time

1 hour, plus your additional time allowance.

Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Complete in black ink only.

All working **must** be clearly shown in the spaces provided.

Marks may be awarded for partially correct solutions.

Answer **all six** questions.

Information for Candidates

The total mark for this paper is 50.

Figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.

You may use a calculator.

- 1 Physicists have discovered the existence of tetraquarks, which are composed of 4 quarks.

There are 6 types of quark: up, down, charm, strange, top and bottom.

- (i) How many different tetraquarks are possible if each is composed of 4 different quarks? [2 marks]

Answer _____

Each of the 6 types of quark can be either ordinary quark or antiquark, so there are 12 possible types of quark.

- (ii) How many different tetraquarks are possible if each must be composed of 4 different quarks chosen from the 12 types? [1 mark]

Answer _____

Some physicists believe that tetraquarks must always contain 2 ordinary quarks and 2 antiquarks.

(iii) How many different tetraquarks are possible if each is composed of 2 different ordinary quarks and 2 different antiquarks? [3 marks]

Answer _____

2 Thomas, a landscape gardener, is going to plant a garden with larch trees and oak trees.

Let x be the number of larch trees and y be the number of oak trees planted.

Thomas is to plant at least 10 but not more than 80 larch trees.

(i) Express this condition as an inequality. [1 mark]

Answer _____

He is to plant at least 5 but not more than 40 oak trees.

(ii) Express this condition as an inequality. [1 mark]

Answer _____

He cannot plant more than 100 trees in total.

(iii) Express this condition as an inequality. [1 mark]

Answer _____

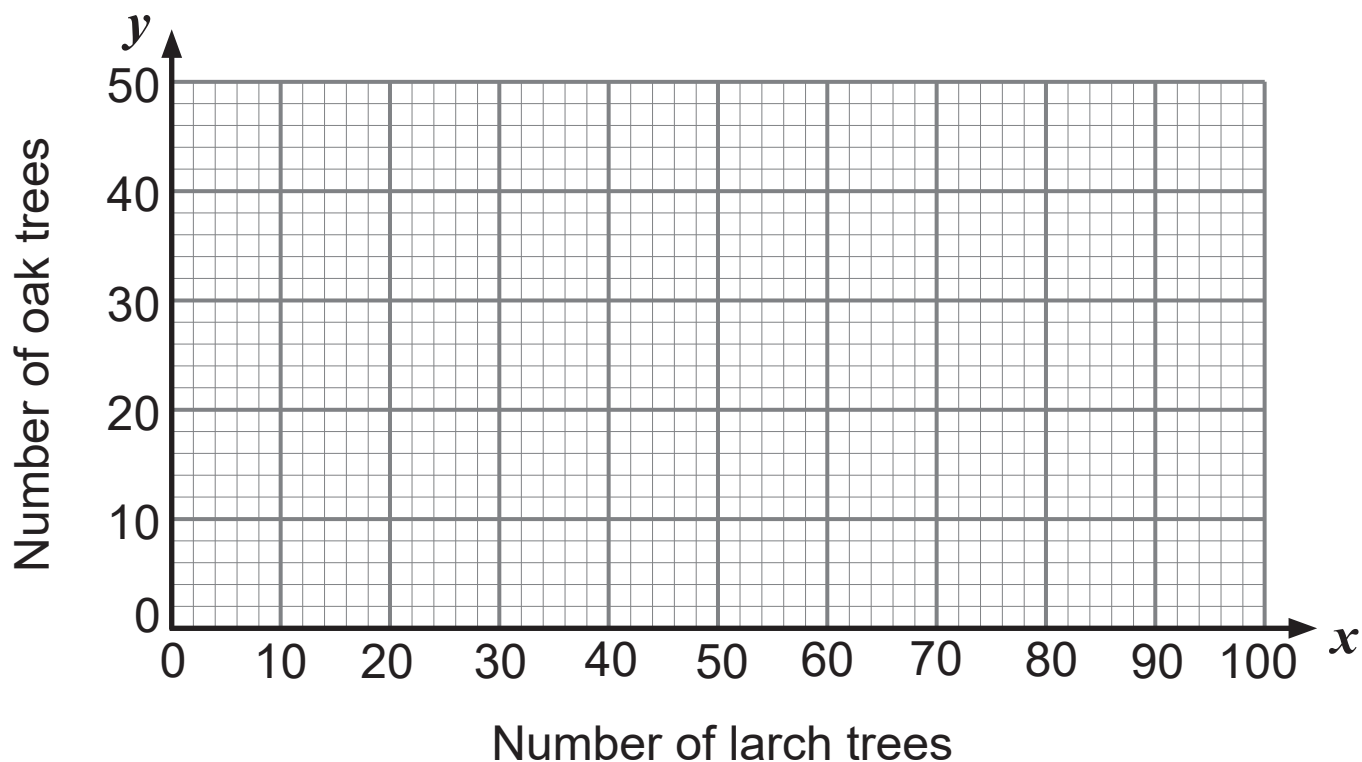
A larch tree needs 20 litres of water each day and an oak tree needs 60 litres of water each day.

There are 3000 litres of water available each day.

(iv) Show that

$$x + 3y \leq 150 \quad [1 \text{ mark}]$$

(v) Illustrate the four inequalities by a suitable diagram on the graph below.



Identify with the letter **R** the region containing the set of points satisfying all four inequalities. [4 marks]

Thomas makes a profit of £20 on each larch tree and £10 on each oak tree.

(vi) Use your solution set to find the maximum profit Thomas can make. [2 marks]

Answer £ _____

Thomas introduces a new pricing structure in which he makes a profit of £10 on each larch tree and £40 on each oak tree.

(vii) Find the new maximum profit Thomas can make and the number of each type of tree he should plant.
[3 marks]

Answer

Maximum profit £ _____

Number of larch trees _____

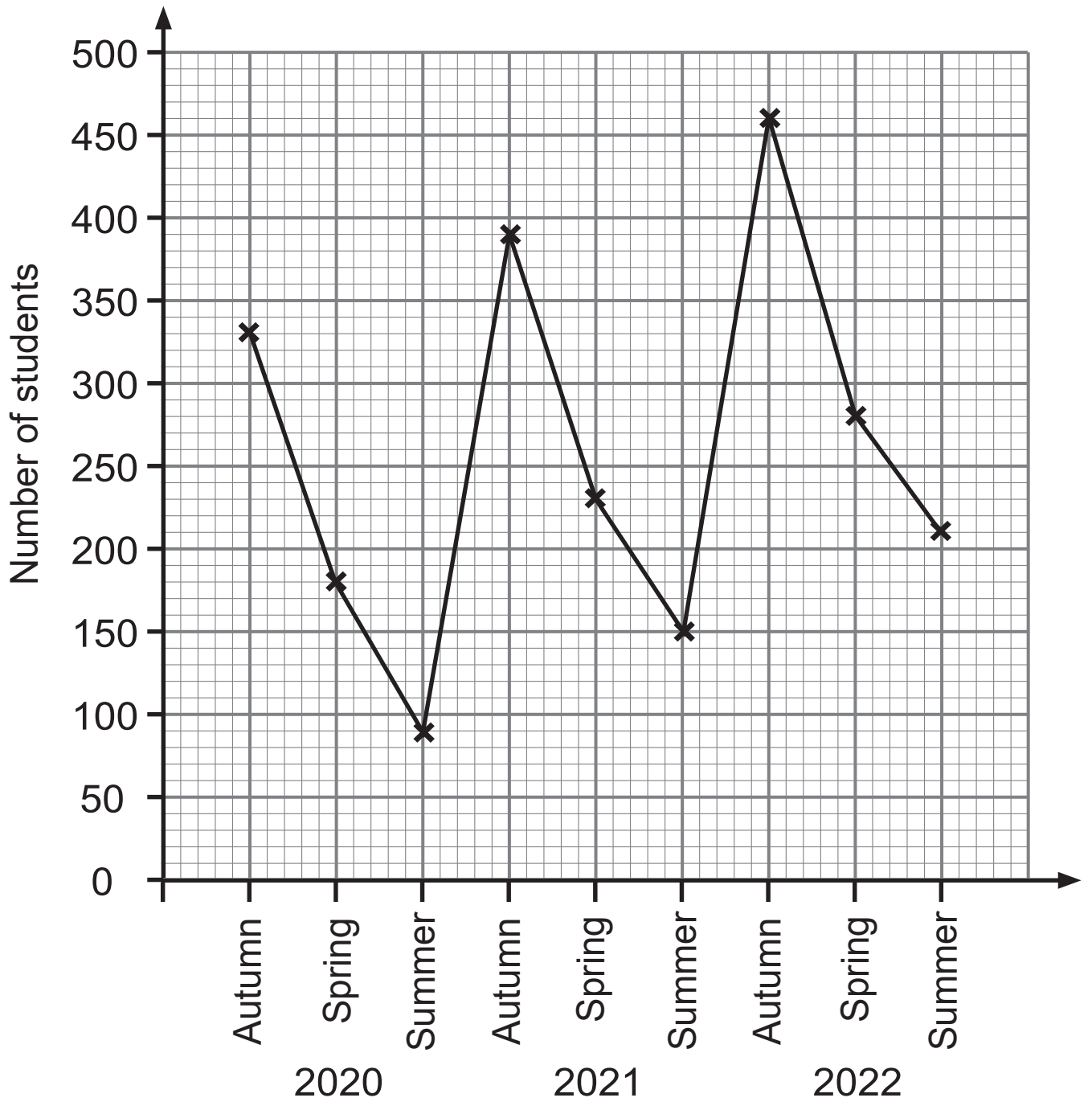
Number of oak trees _____

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(Questions continue overleaf)

- 3** The table below records the number of students who enrolled in courses at a college for each term in 2020, 2021 and 2022

Year	Term	Number of students
2020	Autumn	330
	Spring	180
	Summer	90
2021	Autumn	390
	Spring	230
	Summer	150
2022	Autumn	460
	Spring	280
	Summer	210

These data have been plotted on the graph below.



- (i) Calculate appropriate moving averages to smooth the data, using the information below. Give your answers to 3 significant figures where necessary. [2 marks]

330

180

90

390

230

150

460

280

210

- (ii) Plot these averages on the graph on page 11 and draw the trend line. [3 marks]

- (iii) Showing clearly where any reading is taken, use the trend line to calculate an estimate of how many students are likely to enrol in the Autumn term of 2023 [3 marks]

Answer _____

(iv) State briefly the assumption made when using this trend line to predict future enrolments. [1 mark]

Answer _____

- 4 For any two propositions p and q , the expression " $p \text{ xor } q$ " is true if only one of p or q is true, but false if both are true or both are false.

The expression " $p \text{ xor } q$ " appears in common English as "either p or q but not both".

The truth table for $p \text{ xor } q$ is given below.

p	q	$p \text{ xor } q$
T	T	F
T	F	T
F	T	T
F	F	F

- (i) Complete the truth table for $p \text{ xor } (p \text{ xor } q)$ below.
[2 marks]

p	q	$p \text{ xor } q$	$p \text{ xor } (p \text{ xor } q)$
T	T	F	
T	F	T	
F	T	T	
F	F	F	

- (ii) Hence write the expression $p \text{ xor } (p \text{ xor } q)$ in an equivalent simpler form. [1 mark]

Answer _____

(iii) Complete the truth table below to show that the expressions

not (p xor q) and (p and q) or (not p and not q)

are equivalent. [5 marks]

p	q	p xor q	not (p xor q)	p and q	not p and not q	(p and q) or (not p and not q)
T	T	F				
T	F	T				
F	T	T				
F	F	F				

The propositions p and q are such that

p represents “Bill loves chocolate” and

q represents “Ben plays the drums”.

(iv) Using parts (i) to (iii), write down a simpler form for the **negation** of the compound statement:

“Either Bill loves chocolate and Ben plays the drums,
or Bill doesn’t love chocolate and Ben doesn’t play the
drums.” [1 mark]

Answer _____

- 5 Tom, Jerry and Spike have each got a bag containing coloured objects. Each object is **different** from all the others.

Tom's bag has 3 red and 5 green objects.

Jerry's bag has 4 red, 3 green and 2 blue objects.

Spike's bag has 6 red and 5 blue objects.

In how many different ways can you pick 3 objects, one red, one green and one blue, if you pick one object from each bag? [4 marks]

Answer _____

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(Questions continue overleaf)

6 The diagram opposite shows the activity network used to model a construction project. The activities involved are labelled A, B, C, D, E, F, G, H, I, J, K and L and are represented by the edges.

Each activity requires one builder.

The number on each edge represents the time in days required for a builder to complete that activity.

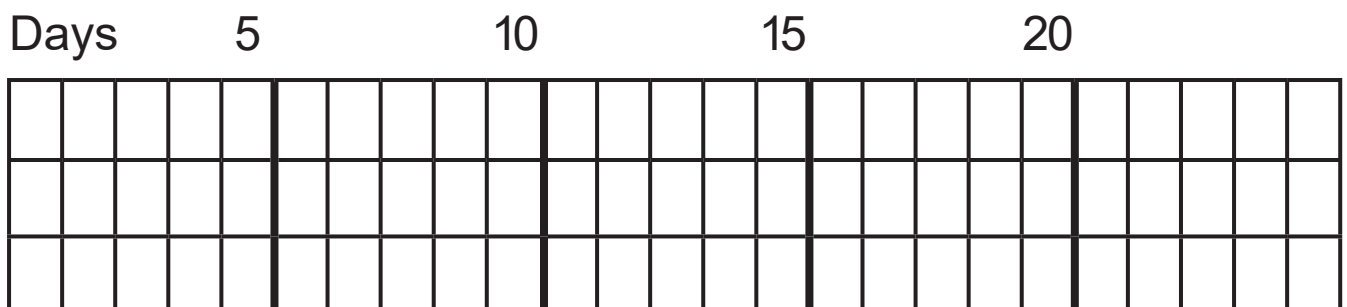
(i) Complete the diagram opposite by filling in the missing early times and late times. [4 marks]

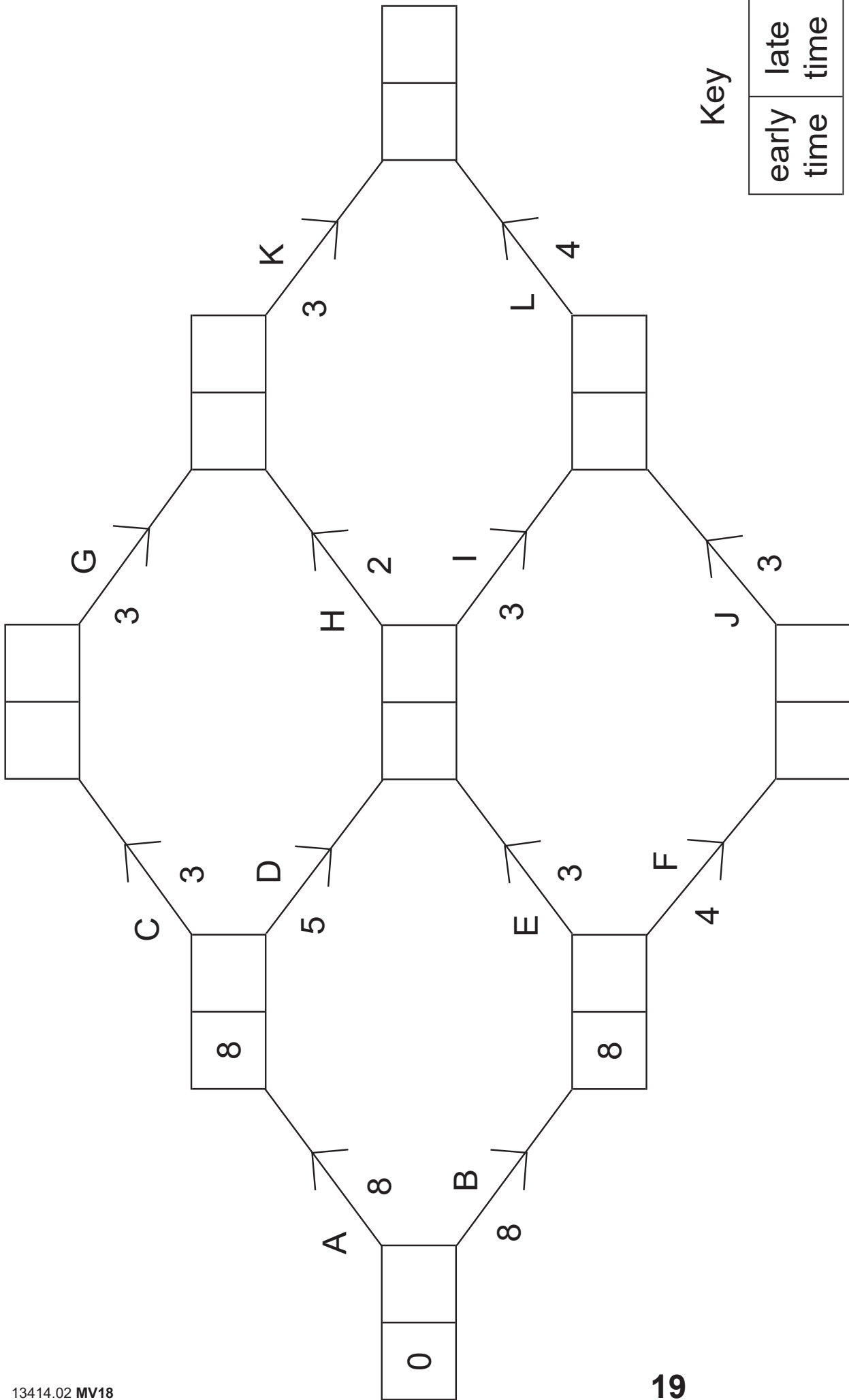
(ii) List the critical activities and determine the length of the critical path. [1 mark for each]

Answer Critical activities _____

Length of critical path _____ days

(iii) Schedule the activities in the chart below so that the project can be completed in the least time by 3 builders, showing clearly the starting and finishing time for each activity. [3 marks]





Key

early time	late time
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This is the end of the question paper

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	

Total Marks	
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Examiner Number

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