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SAMPLE CHAPTER

AQA Level 3

Mathematical Studies (Core Maths)

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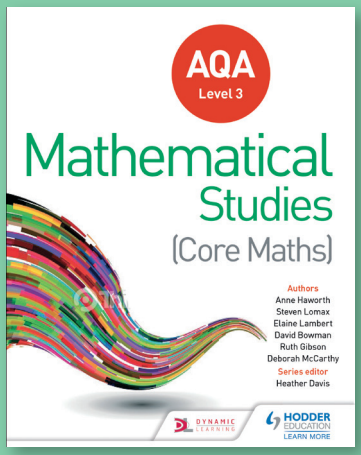

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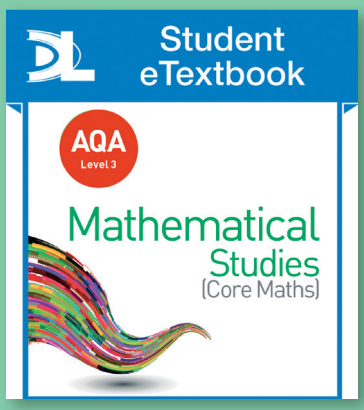

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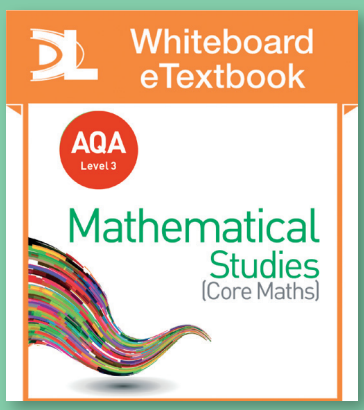

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Paper 2: Options

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HOW TO GET THE MOST FROM THIS BOOK

Sections 1 and 2 of the book cover all the content of the AQA Level 3 Certificate in Mathematical Studies. Section 3 gives you extra explanation, examples and practice for key techniques.

Section 1: Getting started, talking about the maths

This section:

- revisits GCSE knowledge and skills
- develops collaborative working skills
- develops investigational skills
- develops criticality and evaluative skills
- should be done first and worked through in order.

Each Section 1 chapter starts with a scenario that is discussed and investigated in order to teach the content. There are also closed questions to test understanding and questions for practice. The reflect questions are to help students see the usefulness of mathematics and recognise the skills they are developing.

There is a list of process skills and the maths help box gives references to relevant chapters in Section 3.

Section 2: Learning the new stuff

This section:

- develops fluency with the compulsory content and each of the options
- continues to develop skills in collaborative working and investigation
- continues to develop modelling, estimation and criticality skills.

Chapter 2.1 to 2.4 cover estimation and should be done in order.

Chapters 2.5 to 2.10 cover data handling and should be done in order.

Chapters 2.11 to 2.19 cover personal finance and should be done in order.

Chapters 2.20 and 2.21 cover critical analysis and should be done in order.

Chapters 2.22 to 2.43 cover the three options.

Each Section 2 chapter starts with a scenario that is discussed and investigated in order to teach the content. There are also closed questions to test understanding, worked examples and practice questions.

The maths help box gives references to relevant chapters in Section 3.

Section 3: Maths help

This section:

- is a reference section for techniques
- gives additional worked examples and explanations
- gives additional practice questions
- is to be dipped into when appropriate.

Answers

Answers will be provided for all the practice questions and most bulleted questions in the text.

CHAPTER 1.1

VOTING

Do you understand this information?

Does it explain 'first past the post'?

Are elections fair?

What questions do you need to ask?

This is what happened in the 2015 UK General Election:

Do these results seem fair?

First Past the Post Explained

UKIP	3.8 m votes	= 1 MP
Greens	1.1 m votes	= 1 MP
SNP	1.5 m votes	= 56 MPs

How could you show whether these results are fair or not?

It is easy to say that results are unfair when we disagree with them, but harder to back up our statement when we are challenged. Processing the data helps to make the case, but can also be used to make whatever case you want it to!

WHAT YOU NEED TO KNOW ALREADY

- Using fractions and percentages
- Interpreting tables, charts and diagrams
- Calculating averages and range

MATHS HELP

Chapter 3.2 Spreadsheet formulae
Chapter 3.8 Representing and analysing data
Chapter 3.15 Percentages

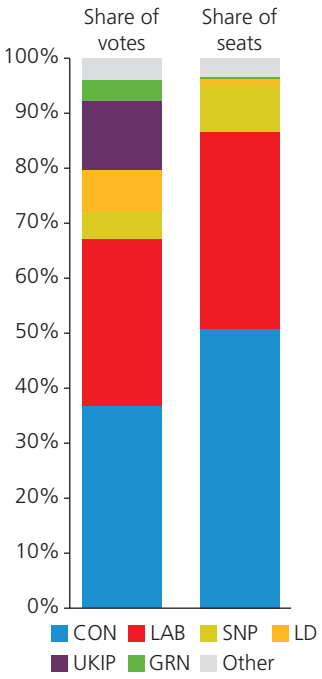
PROCESS SKILLS

- Researching
- Using spreadsheets
- Representing data
- Interpreting data

Investigate

More detail about the results of the 2015 General Election is available on line – search for it!

- You could vote for most of the parties in each of the four countries of the UK – which parties? Which parties could you vote for in only one of the UK's countries? Is that fair?
- Set up a spreadsheet to calculate, for each of the parties, how many votes were cast for each seat. You may wish to focus on your own region.
- Draw some charts and graphs using the options on the spreadsheet. Do they help to communicate the data?
- Calculate the mean and the median number of votes cast per seat. Which do you think best represents the data?



Discuss

- What do your charts show? What sort of chart do you think shows the data most clearly – and why?
- What is meant by 'first past the post' and 'proportional representation' voting systems? Which is fairer?
- Would this data encourage you to consider proportional representation rather than first past the post to elect your Members of Parliament?

QUESTIONS

1 For England, set up a spreadsheet to draw charts to compare the number of seats actually won by each party in 2015 with the number of seats they would have won if the seats had been distributed in proportion to the number of votes cast. Would a proportional system have affected the outcome of the election?

2 What different systems of proportional representation can be used? Investigate what systems are used in other countries. Which do you think is best?

Reflect

What did you learn about the election of MPs while working on this task?

Did you contribute to the debate?

Were you able to use a spreadsheet?

Have you improved your skills in working with data?

CHAPTER 2.5

CAMPAIGNING FOR CHANGE

I know I'm right

How can I prove it?

How can you effectively make your point heard?

How can I make them listen?

How can these statements both be true?

Ashingford News
Overcrowding on local commuter trains

A commuter organisation says that 21% of trains are overcrowded but the rail company says the average number of passengers per train arriving in Ashingford is 239. There are 320 seats per train so there is plenty of space.

WHAT YOU NEED TO KNOW ALREADY

- Calculating the mean and median for raw data
- Using tally marks to create a grouped frequency table

MATHS HELP

Chapter 3.7 Statistical terms
Chapter 3.8 Representing and analysing data
Chapter 3.10 Calculating statistics
Chapter 3.11 Diagrams for grouped data

PROCESS SKILLS

- Modelling the data using diagrams
- Interpreting statistical diagrams
- Representing data graphically and numerically
- Summarising a statistical argument

Things are not always how we would like them to be. When things are challenged, a number is often quoted as a justification. This tends to be a statistic, such as an average, or percentage of the population concerned with a particular characteristic. In many cases the statistic is not presented with the context that it needs to be valid, and sometimes it is not even true. It does, however, carry considerable weight and people tend to believe it because it sounds like there is a calculation behind it. In order to get things changed, it is always useful to put forward a case based on real data. This chapter explores how to present data clearly when the data is quantitative and discrete.

DID YOU KNOW?

Data recorded as a description, such as type of car (for example, Skoda), is called **qualitative** data. Most of the time we deal with **quantitative** data – data that is a number. When measurements such as length, weight and volume make up the data, the data is called **continuous** because all values in a specific range are possible. This is dealt with in Chapter 2.2.

In this chapter we are dealing with **discrete** data, which tends to be (but is not solely) whole numbers that result from counting things such as numbers of passengers.

The trouble with quoting single figures such as the mean, median, or a percentage is that it does not allow you to get a full picture of the data. A diagram showing the distribution of the data itself can be very useful. Here are three ways of doing this:

- Stem-and-leaf diagrams
- Grouped frequency tables
- Box and whisker diagrams.

Here are the number of passengers on every train arriving at Ashingford in one particular week in May.

4	7	9	25	159	256	55	56	57	59
102	104	111	111	112	143	115	118	118	123
200	299	281	207	208	280	214	280	219	224
311	261	268	337	340	345	349	289	364	378
269	271	445	460	467	294	147	153	77	250
513	537	544	567	574	587	186	197	198	65
639	646	653	77	80	84	240	243	243	68
164	164	177	184	244	114	434	440	125	140
217	243	324	337	256	213	153	155	228	234
361	165	161	163	38	51	203	204	388	167

Discuss

- Do you think there were overcrowded trains the week this data was recorded?
- How many passengers do you think a train needs to have in order to be classified as overcrowded?
- How many trains do you think were overcrowded?
- When do you think these were?
- What problems would you have calculating the mean of this data?

It would be easier to understand the data if it was organised in some way.

Below, the data has been collected into a **grouped frequency table.**

No. of passengers	Tally	Frequency (f)
$0 \leq p < 50$	𝍸	5
$50 \leq p < 100$	𝍸 𝍸 I	11
$100 \leq p < 150$	𝍸 𝍸 IIII	14
$150 \leq p < 200$	𝍸 𝍸 𝍸	15
$200 \leq p < 250$	𝍸 𝍸 𝍸 III	18
$250 \leq p < 300$	𝍸 𝍸 II	12

No. of passengers	Tally	Frequency (f)
$300 \leq p < 350$	𝍸 II	7
$350 \leq p < 400$	IIII	4
$400 \leq p < 450$	III	3
$450 \leq p < 500$	II	2
$500 \leq p < 550$	III	3
$550 \leq p < 600$	III	3
$600 \leq p < 650$	II	2
$p \geq 650$	I	1

HINT

A train with 350 passengers would be included in the group $350 \leq p < 400$. A train with 400 passengers would be included in the next group $400 \leq p < 450$. When choosing groups make sure every number is included in one and only one group.

Discuss

- In the grouped frequency table above, the same data has been grouped into group sizes of 50. How can you tell that from the table?
- There are four items of data in the group $350 \leq p < 400$. What are their values?
- What do these values represent?

A good way to work out the mean is from a grouped frequency table.

WORKED EXAMPLE

Estimate the mean number of passengers.

SOLUTION

No. of passengers	Frequency (f)	Mid point (m)	$m \times f$
$0 \leq p < 50$	5	25	125
$50 \leq p < 100$	11	75	825
$100 \leq p < 150$	14	125	1 750
$150 \leq p < 200$	15	175	2 625
$200 \leq p < 250$	18	225	4 050
$250 \leq p < 300$	12	275	3 300
$300 \leq p < 350$	7	325	2 275
$350 \leq p < 400$	4	375	1 500
$400 \leq p < 450$	3	425	1 275
$450 \leq p < 500$	2	475	950
$500 \leq p < 550$	3	525	1 575
$550 \leq p < 600$	3	575	1 725
$600 \leq p < 650$	2	625	1 250
$p \geq 650$	1	700	700
Totals	**100**		**23 925**

When you put data into a grouped frequency table, the actual values are lost and it is assumed that all data takes the value of the midpoint of the group. So the total number of passengers on the four trains in the group $350 \leq p < 400$ is estimated at 1500, whereas the actual total was 1491. For this reason, any calculations will only give us an estimate.

Alternatively, a spreadsheet can be used with the raw data. This would give an accurate mean of 237.2

Discuss

- Explain where all the numbers in the grouped table above come from.
- How different is the estimate from the accurate mean?
- Do you think this matters?

In one week in August, the numbers of passengers were recorded on the trains arriving at Ashingford.

The data is organised in a **stem-and-leaf diagram.**

The digits to the left of the vertical line are called **stems** and those to the right are the **leaves**.

Notice that the leaves are arranged in ascending order.

0	4	6	7	8	9		
1	0	1	5	7	8	8	
2	4	5	6				
3	2	2	4	6	7	8	9
4	3	4	5	6	7	7	
5	0	2	6				
6	5	6					
7	5	6	8				
8	0	1	5				
9	3	5	6				
10	4	5	6	6			
11	0	0	1	5			
12	3	4	6	8	8		
13	0	1	2	4	6		
14	4	5	5	7	7	8	
15	3	3	4	5	6	7	8
16	4	5	6	6	7	8	8
17	0	1	2	3	4	5	5	7
18	0	0	2	4	4	5	
19	1	4	7				
20	2	5					
21	3	5					

Key 11 | 5 means 115

Discuss

- Look at the key. One train had 115 passengers, represented by a stem of 11 and a leaf of 5. Can you find this train within the table?
- Which of the following numbers of passengers were also recorded as part of the data?

  105 15 5 115 150 250

Investigate

Display this data as a grouped frequency table. Find an estimate for the mean using your grouped frequency table.

Compare the data collected in August with the data collected in May. What do you notice? Give a possible reason for these differences.

DID YOU KNOW?

The stems could be 'doubled up' to simplify the diagram. The line beginning at 7 would become:

7 | 5 6 8 10 11 15

HINT

A stem and a leaf can represent different amounts. For example, 34 | 5 can represent 345, 34.5 and 3.45. This is why having a key is vital.

HINT

Stem-and-leaf diagrams and grouped frequency tables tend to be most useful when there are between 5 and 15 stems or groups.

Discuss

› How many stems would there be if you represented the May data as a stem-and-leaf diagram?

Another diagram used to represent data is a **box and whisker** diagram (also known as a **box plot**). This uses the median and quartiles to give a diagrammatic representation of the shape of the distribution of the data.

The median and quartiles are most easily found from an ordered set of data or from a stem-and-leaf diagram.

WORKED EXAMPLE

Find the median and quartiles of the data below.

4	7	9	25	38	51	55	56	57	59	65	68	77	77	80	84	102	104	111	111
112	114	115	118	118	123	125	140	143	147	153	153	155	159	161	163	164	164	165	167
177	184	186	197	198	200	203	204	207	208	213	214	217	219	224	228	234	240	243	243
243	244	250	256	256	261	268	269	271	280	280	281	289	294	299	311	324	337	337	340
345	349	361	364	378	388	434	440	445	460	467	513	537	544	567	574	587	639	646	653

SOLUTION

The median item of 100 pieces of data is the $\frac{1 + 100}{2} = 50.5^{\text{th}}$ item, so the median is the mean of the 50^{th} and 51^{st} items. It is halfway through the data.

So **median** $= \frac{208 + 213}{2} = \frac{421}{2} = 210.5$

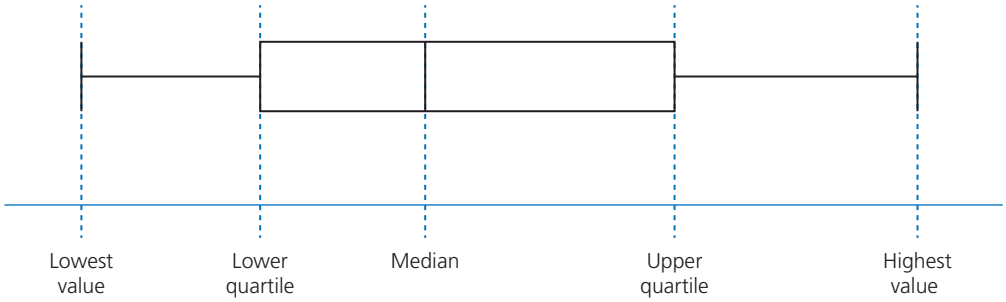
The lower quartile is the middle item of the first half of the data, the $\frac{1 + 50}{2} = 25.5^{\text{th}}$ item, so the lower quartile is the mean of the 25^{th} and 26^{th} items. It is a quarter of the way through the data.

So **lower quartile** $= \frac{118 + 123}{2} = \frac{241}{2} = 120.5$

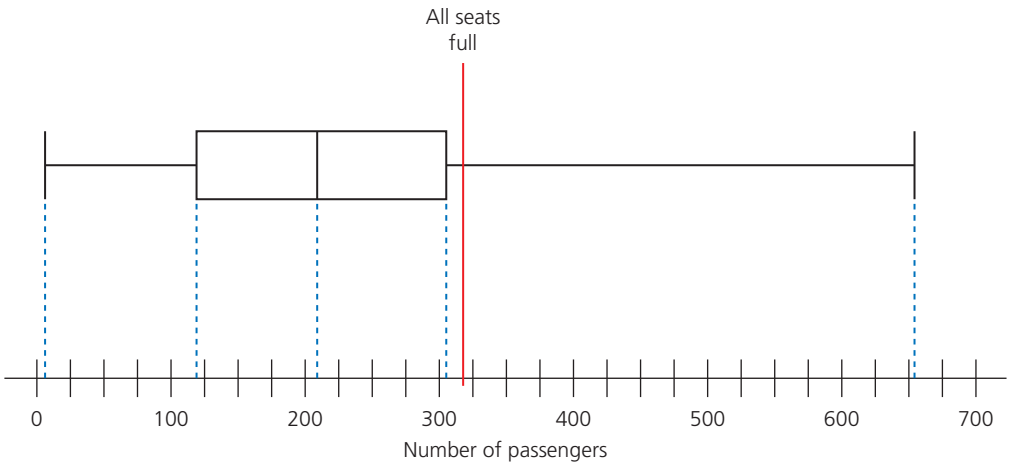
The upper quartile is the middle item of the second half of the data, the $\frac{51 + 100}{2} = 75.5^{\text{th}}$ item, so the upper quartile is the mean of the 75^{th} and 76^{th} items. It is three-quarters of the way through the data.

So **upper quartile** $\frac{299 + 311}{2} = \frac{610}{2} = 305$

Box and whisker diagram



Using these measures to draw a box and whisker diagram to scale as above, gives the following:



By adding the line that shows when all the seats are full, we can see that almost a quarter of the trains have more passengers than seats. Box and whisker diagrams are particularly useful when comparing two sets of data.

HINT

Reports should be brief and focused. Only the diagrams and calculations that are really helpful should be included. The writing should pick out the main arguments and points and come to a conclusion.

Investigate

› Draw a box and whisker diagram for the passenger data collected in August. Make a note of the differences between the two box and whisker diagrams.

Discuss

› Put together a short article from the point of view of the commuter organisation, with appropriate diagrams and measures, to demonstrate that there is overcrowding on Ashingford trains.

QUESTIONS

1 **a** Which of these are quantitative data?

b Which are qualitative data?

Subjects studied; number of people studying each subject; exam marks; exam grades; holiday destinations; holiday prices; how much people earn.

c Think of more examples of qualitative and quantitative data.

2 A website designer wants to demonstrate the effect she has had on the number of hits received by a customer's website. She records the number of hits each day in the month before she makes the changes and each day for a month after she has made all the changes.

The data obtained is recorded in the back-to-back stem-and-leaf diagram below.

a Calculate the mean and median number of hits both before and after her changes.

b What evidence is there that she has increased the number of hits?

c What evidence is there that she has **not** increased the number of hits?

Number of website hits

Before								After								
			8	8	5	3	0	0	0	2	2	3	7	7		
9	7	7	5	4	4	4	1	0	1	4	7	7	7	8	8	9
		8	7	5	5	3	2	1	2	2	4	6	7	7	8	8	8	9
			9	8	7	7	6	6	3	5	6	7	7	8	8	9	9	
						2	1	0	4									
									5	6								

Key 6 | 3 | means 36

3 The villagers of Trowford are campaigning for a village bypass. For one complete week, they count the number of lorries passing the village church each hour between 7 a.m. and 7 p.m. They record the following data.

6	12	14	26	35	23	36	23	32	26
12	3	5	13	24	23	34	31	31	28
10	7	7	6	11	24	34	38	32	34
23	34	32	22	12	12	35	32	41	21
32	37	27	23	25	24	23	7	9	11
17	26	23	27	32	32	26	14	13	10
6	8	10	11	12	12	10	14	12	4
3	2	0	0	0	0	2	1	2	1
0	0	0	0						

a Use either a stem-and-leaf diagram or a grouped frequency table to summarise this data. Justify your choice of diagram.

b Calculate the mean and median number of lorries each hour over the week.

c What advice would you give the villagers in order for their campaign to have the greatest impact?

4 A bird conservation group is investigating whether there has been any growth in guillemot breeding along a particular piece of cliff. They photograph the cliff at midday every day in May in two consecutive years and then count the number of birds they can see.

The results are shown in this back-to-back stem-and-leaf diagram.

Year 1					Year 2						
			3	18							
		7	3	19	2						
	6	5	4	0	20	3	5	6			
	7	6	2	2	21	4	5				
	9	8	6	5	22	5	7	9			
7	6	4	2	1	23	5	6	7	6	8	9	9
8	7	5	3	0	24	3	4	5	6	8	8	
		3	3	2	25	0	1	3	5			
			1	0	26	2	4	5	7			

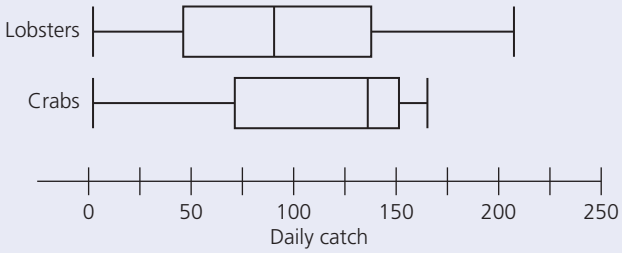
Key | 26 | 2 means 262

a Looking at the stem-and-leaf diagram, do you think there is any evidence that the number of Guillemots on the cliff has increased in year 2? Explain your answer.

b Draw a box and whisker diagram for year 1 and year 2 using the same scale.

c Compare your two box and whisker diagrams to quantify the differences between the two years.

5 Peter is a fisherman. During the lobster season he catches crabs and lobsters in his lobster pots. He records his catch each day of the season and the data is summarised in the box plots below.



Compare his daily catch of crabs and lobsters.

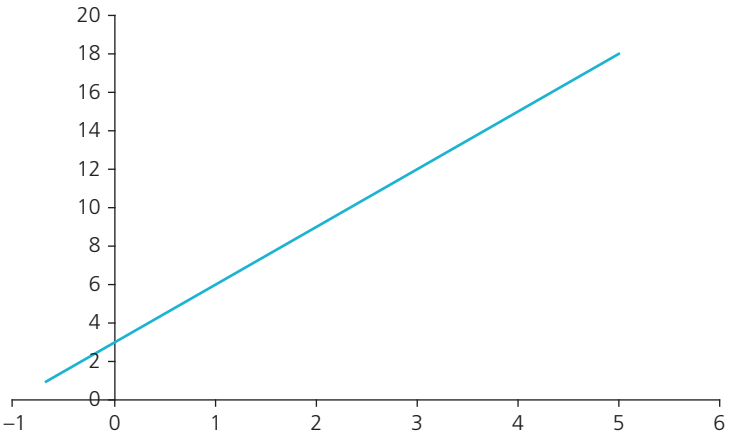
HINT

Quantify means you have to give some numbers to back up your statements.

CHAPTER 3.1

STRAIGHT LINE GRAPHS

Finding the gradient of a straight line



To find the gradient of any line, first choose two points on the line.

HINT

It is easier to choose two points that are as far away from each other as possible and whose coordinates are easy to determine.

HINT

Remember / has a positive gradient and \ has a negative gradient.

To find the gradient between the two points

Think of the line between the two points as the hypotenuse of a right-angled triangle.

Find the lengths of the vertical and horizontal lines of the triangle.

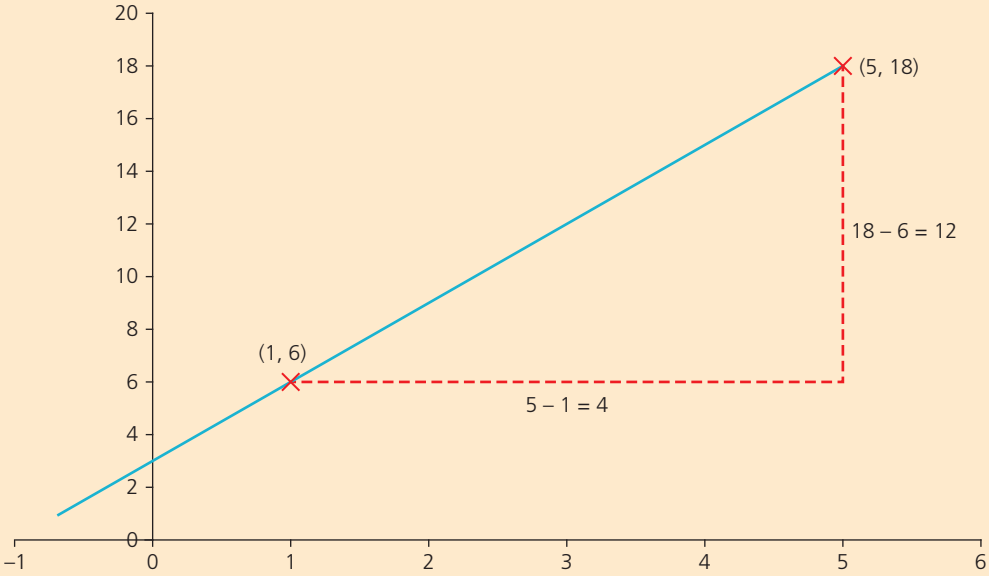
$$\text{Gradient of the line between the two points} = \frac{\text{Vertical distance}}{\text{Horizontal distance}}$$

WORKED EXAMPLE

Find the gradient of the line above.

SOLUTION

Possible points on the line to choose could be (1, 6) and (5, 18).



$$\text{Gradient of the line} = \frac{\text{Vertical distance}}{\text{Horizontal distance}}$$
$$= \frac{12}{4}$$
$$= 3$$

Equation of a straight line

The equation of a straight line is of the form

$y = mx + c$

where m is the gradient of the line

and c is the y-intercept.

Note: Vertical lines are an exception to this rule. A vertical line going through $(a, 0)$ has an equation

$x = a$.

WORKED EXAMPLE

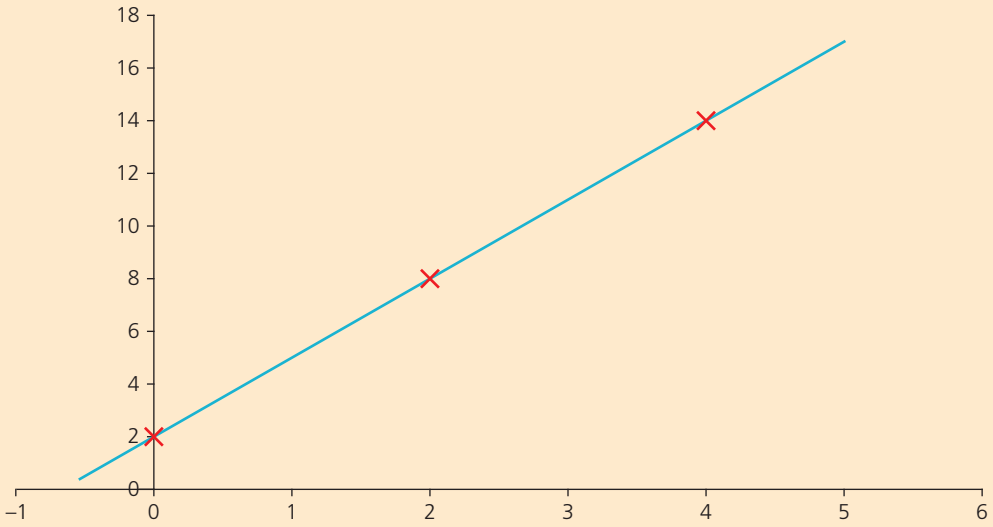
Plot the graph of $y = 3x + 2$

SOLUTION

This is a straight line graph with gradient 3 and y-intercept at $(0, 2)$.

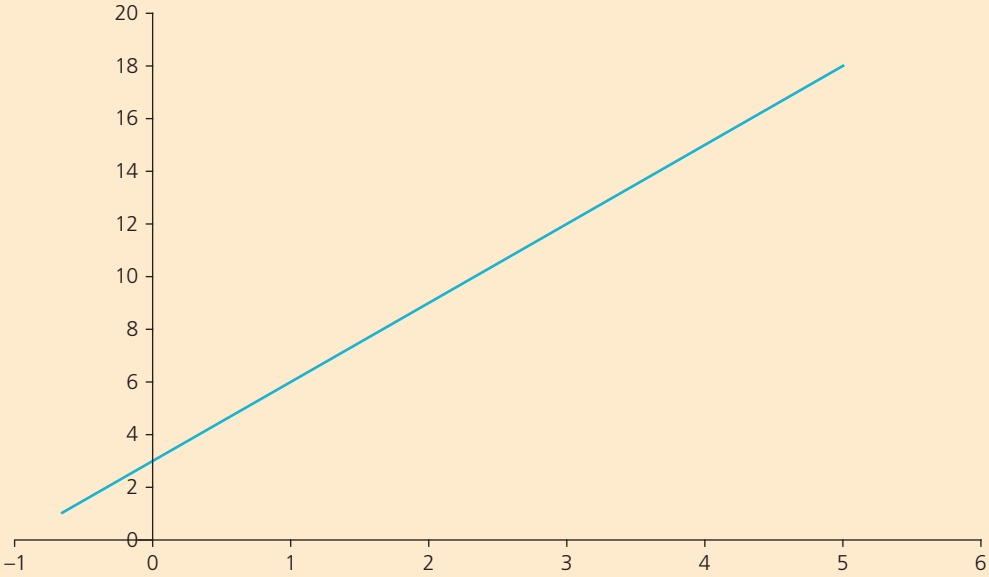
Plot the graph by finding three points on the line (you need two to draw the line plus a check point).

x	0	2	4
$y = 3x + 2$	2	8	14



WORKED EXAMPLE

Find the equation of this line.



SOLUTION

To find the equation of the line we need to know its gradient and y-intercept.

As in the example above, the gradient of the line is 3.

By inspection, looking at the graph, the line crosses the y-axis when $y = 3$. This is the y-intercept.

So the equation of the line is $y = 3x + 3$

HINT

If the y-intercept is not visible on the graph, take any point on the line and substitute the coordinates into $y = 3x + c$

e.g. The point (1, 6) lies on the line, so

$6 = 3 \times 1 + c$

$6 = 3 + c$

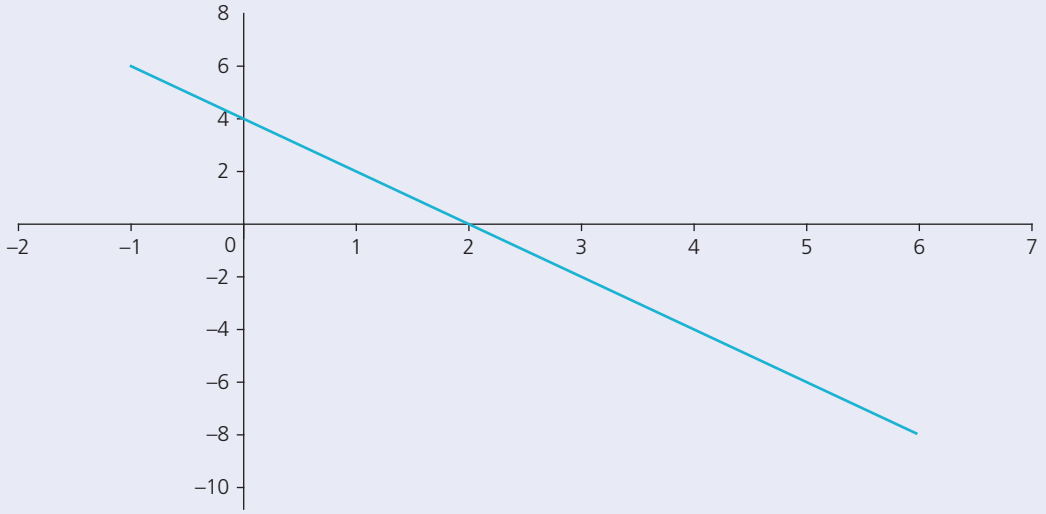
$c = 3$

QUESTIONS

1 **a** Using x and y axes from –2 to 6, draw the line $y = x - 1$.

b State the gradient of this line.

2 **a** Find the gradient of this line.



b State the equation of the line.

3 **a** Plot the points (–4, 1) and (6, –11) on a graph.

b Find the gradient of the line joining the two points.

c On the same graph, draw the line $y = 1 - x$.

d What do you notice about the two lines?

4 Here are the equations of five lines.

A $y = 4x + 4$

B $y = 4 - 4x$

C $y = 4 + 5x$

D $y = 5x - 4$

E $y = 4$

a Which lines have the same y-intercept?

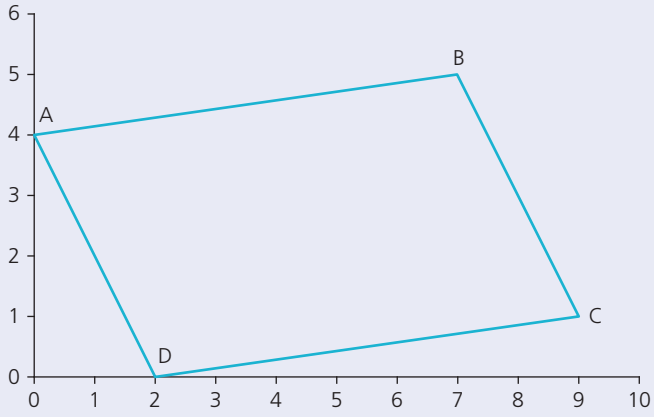
b **i** Which lines have the same gradient?

ii Plot the lines with the same gradient on the same graph.

iii What do you notice about these lines?

c What is the equation of the line at right angles to $y = 4$ passing through the point (3, 2)?

5 ABCD is a parallelogram. Find the equations of lines AB, BC, CD and DA.



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