# Reading: Exercises on Teaching Data Handling

A reading to accompany Unit Five of the module:
*Teaching and Learning Mathematics in Diverse Classrooms*

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# Reading: Exercises on Teaching Data Handling

## Overview

This set of exercises has been adapted from materials that lecturers at the RADMASTE centre at the University of Witwatersrand prepared to support the teaching of data handling for the Advanced Certificate of Education in Mathematics Education for the GET phase.

Learners will gain skills to make sense of data by gathering data, organising and interpreting data and drawing conclusions from the data collected. These processes are appropriate for learners because they can be used to solve problems that are interesting to them. They can also represent significant applications of mathematics to practical questions. There are many graphs used to represent statistical data. Learners have to work with these graphs to gain an understanding of how to interpret and communicate the information represented in graphical form.

# Collecting Data

The data that you collect in a survey or questionnaire may be very varied – it may be about the colour of people's eyes, their mode of transport to work, an opinion (which chocolate do you prefer?) or a like or dislike. It may also be numerical, such as how many cars come through the school gate in the morning?

There are two forms of numerical data:

- Information that is collected by counting is called discrete data. The data is collected by counting exact amounts, e.g. the number of children in a family; the number of children with birthdays in January; the number of goals scored at a soccer match.
- Continuous data is collected by measurement and the values form part of a continuous scale, e.g. the height of learners in a Grade 8 measured in centimetres and fractions of a centimetre; temperature measured in degrees and fractions of a degree.

The mass of a baby at birth is continuous data, as there is no reason why a baby should not have a mass of 3,25167312 kg – even if there is no scale that could measure so many decimal places. However, the number of children born to a mother is discrete data, as decimals make no sense here.

## Tables, lists and tallies

When you first look at data, all you may see is a jumble of information. You need to sort the data and record it in a way that puts order into it so that it makes more sense.

Some data is easy to sort into lists that are either numerical or alphabetical. Other data can be sorted into tables. Some tables can be used to keep count of the number of times a particular piece of data occurs. Keeping count like this is called keeping a tally. There is an example of a tally table in the activity below. If you need to learn more about tally tables you'll be able to find the information in an intermediate phase mathematics text book. Another name for such a tally table is a frequency table. The frequency of something happening is the number of times it happens.

The content in the exercise that follows relates to the assessment standards on collecting (using a survey and by experimenting) and organising data. There are also some interpretive questions based on the data.

Exercise 1

1 A survey was conducted to find the ten most spoken languages in the world and the number of people speaking them. The results were written out as follows:

| | | | |
|---|---|---|---|
| Chinese: | 700 million | German: | 119 million |
| English: | 400 million | Spanish: | 240 million |
| Russian: | 265 million | Japanese: | 116 million |
| Bengali: | 144 million | Arabic: | 146 million |
| Hindustani: | 230 million | | |

Organise the information into an ordered list in two different ways.

2 In an experiment I toss a dice 50 times and keep a record of the number that appears each time. The numbers are shown below:

2 ; 4 ; 3 ; 3 ; 1 ; 5 ; 6 ; 3 ; 2 ; 2
2 ; 2 ; 6 ; 1 ; 5 ; 5 ; 3 ; 3 ; 4 ; 2
2 ; 3 ; 4 ; 3 ; 6 ; 5 ; 1 ; 1 ; 2 ; 1
3 ; 5 ; 6 ; 3 ; 1 ; 2 ; 2 ; 5 ; 5 ; 1
6 ; 2 ; 2 ; 4 ; 1 ; 6 ; 2 ; 3 ; 3 ; 5

Complete the tally table and then answer the questions.

| Number | Tally | Frequency |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| Total | | |

Notice:

- The tally total is the same as the frequency total
- The data can go across or down the page.
- The ‘items’ come first in the table.
- Do not confuse the frequency with the number on the dice

- How many threes were tossed?
- What number was tossed the most times?
- Why do you think more sixes were not tossed?
- How many more times was a two tossed compared to a five?
- Do you think this dice is a fair dice? What does fair mean in this question?

3 Conduct a simple survey of the learners in your class to ask about the months of their birthdays.

- Record the information in a frequency table:

| Month | Tally | Frequency |
|---|---|---|
| January | | |
| February | | |
| March | | |
| April | | |
| …….. | | |

- In which month do most birthdays occur?
- In which month do the least birthdays occur?

# Representing data

Once you have collected the data, you have to be able to display it in a way which effectively communicates the information that you have found. This can be done by means of picture diagrams and several different forms of graphs. Presenting data visually means that it is easier to read and make sense of.

## Pictograms

Suppose you collected the birthday months of all the learners in your class. You could organise this information into a table like this:

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mmatsie | Sipho | Abdul | Thandi | Jonas | Mary | Cita | Anna | Alix | Farah | Rachel | Adit |
| Jama | Zeta | | Michael | | Jabu | Jo | Makhosi | Sandep | Peg | | Devy |
| | Beth | | Zoe | | | Ahmed | Puleng | Jane | Pumlani | | |
| | | | | | | | Chandra | Zula | | | |
| | | | | | | | | Fatima | | | |

If you are primarily interested in how many learners have birthdays each month their names do not matter. You can represent each child with a symbol –

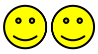
 **= 1 learner**

You can rearrange the list of names in this way:

Birthdays in Grade 8

2 learners have birthdays in January – draw two faces

One learner has a birthday in May – draw one face

| | |
|---|---|
| Jan. |  |
| Feb. | |
| March | |
| April | |
| May |  |
| June | |
| July | |
| August | |
| September | |
| October | |
| November | |
| December | |

Complete the table with faces for the other months.

Key:

 = 1 learner

Redraw this table and complete the pictogram.

This method of displaying the data is called a 'pictogram'. You can clearly see how many children have birthdays in each month. Pictograms are useful as they provide a quick visual impression of the data.

If you had collected a lot of data – say birthday months of everyone in the school – there might be 30 or more in one month. It would be tiresome to draw so many little faces so you could choose a scale – say 1 face represents 10 people. This explains why all pictograms need a key to say what the symbol or ‘picture’ represents.

When drawing pictograms there are a number of things to remember:

- All pictograms must have a title and a key.
- Choose a simple ‘picture’ or symbol that is easy to draw.
- Always give a key and say clearly what each symbol stands for. If

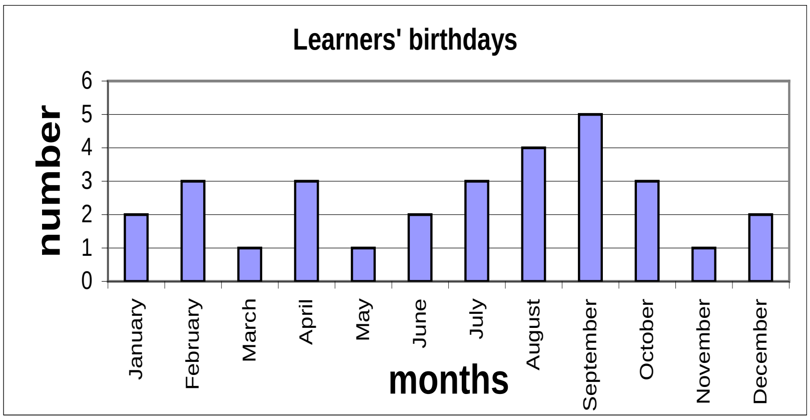
 = 10 people, you will need to draw

 = 5 people

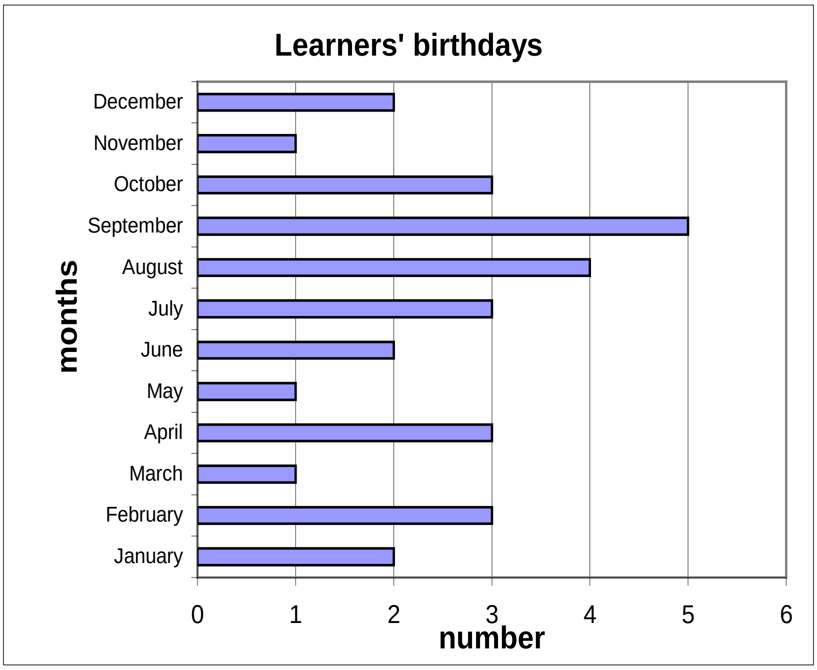
- Work out how many symbols you need for each data column or row carefully.
- Draw on squared paper as this helps keep the symbols neatly in line.

## Bar graphs

Another way of displaying the birthdays would be to put them in a vertical chart like this:



Or a horizontal chart like this:




This method of displaying the data is called a 'bar chart' or 'bar graph'. This is a very popular way of displaying information, as it is easy to read accurately and gives a very good visual impression of the data. A bar graph uses bars, side by side, to display information. A bar graph shows clearly how data items compare – you can see at a glance which bar is longer – however it is difficult to compare one item of data to the whole data set. A bar graph can show frequencies – numbers of things, as in the birthdays above; or amounts of things such as heights of mountains, or hours spent watching TV.

Notice:

1 The bars can be horizontal or vertical.

2 The length of the bar stands for the frequency of the data.

3 A bar graph has two axes – the scales of the axes must be accurate.

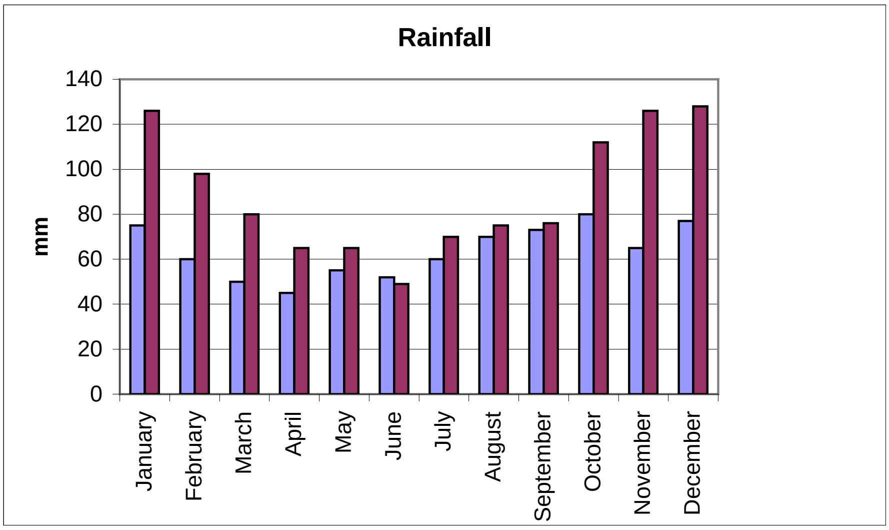
4 All bars are the same width.

5 All bar graphs have a title

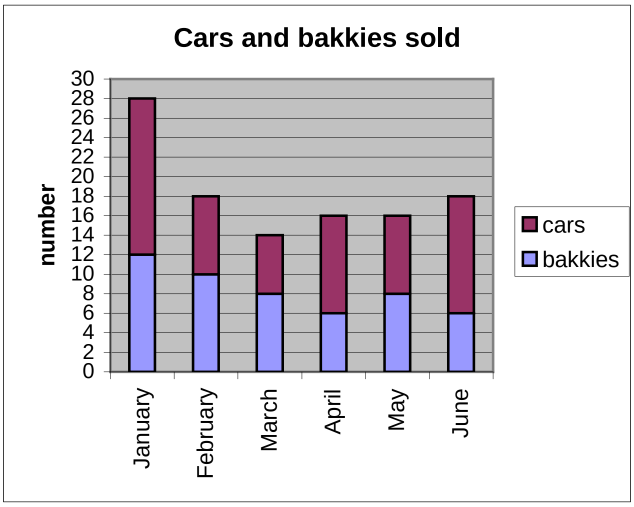
6 Bar graphs can be used for discrete and continuous data

7 Bar graphs can also be used to illustrate grouped data

8 Sometimes a bar graph has two sets of bars - representing different data side by side. This allows you to compare two sets of data on one graph rather than on two graphs. The bar graph below shows the rainfall at two different places on one graph.




9 Sometimes a bar graph has different sets of data on the same topic shown as different sections on a bar. This is called a sectional bar graph.




This bar graph shows the number of bakkies and cars sold by a garage in 6 months

Exercise 2

1 The table below shows the estimated percentage HIV prevalence per province in South Africa in 1998.

| Province | % |
|---|---|
| Eastern Cape | 16 |
| Free State | 22 |
| Gauteng | 22 |
| KwaZulu-Natal | 33 |
| Mpumalanga | 30 |
| Northern Cape | 10 |
| Limpopo | 12 |
| North West | 21 |
| Western Cape | 5 |
| **South Africa** | **22** |

This means that 16% of the population of the Eastern Cape is estimated to be HIV positive.

- Show this information in a pictogram. Use  as a symbol that represents 5 %.
- Draw a vertical bar chart to show the information. Put the provinces on the horizontal axis and percentages on the vertical axis.
- From what you know about the HIV/AIDS pandemic do you think the graph would look the same today? Discuss this with your group.

2 The table below shows the percentage of households in South Africa that have 2 or fewer rooms. The data is listed by province and is an estimate taken in 1996.

- Draw a bar chart to represent this information.
- Discuss with your group why you think the percentage is lower in the Western Cape. Write down the main ideas from your discussion.

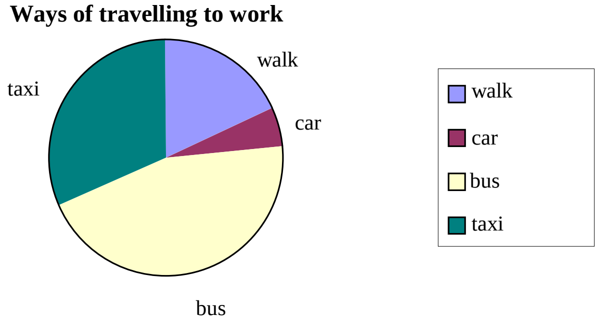
| Province | % |
|---|---|
| Eastern Cape | **39** |
| Free State | **37** |
| Gauteng | **36** |
| KwaZulu-Natal | **35** |
| Mpumalanga | **33** |
| Northern Cape | **39** |
| Limpopo | **29** |
| North West | **28** |
| Western Cape | **23** |
| **South Africa** | **33** |

This means that 33% of households in Mpumalanga have 2 or fewer rooms.

## Pie charts

A pie chart is another way of representing data. A pie chart is a circular diagram divided up into 'slices' like a pie. It is particularly useful if you want to illustrate a whole population divided into parts and show what portion of the whole each part represents. The whole circle represents the whole population. Each slice represents a part of the whole. The size of the slice shows the size of that part.

This pie chart shows the way a group of people travel to work. It is easy to see that most people go by bus.




Pie charts are very tedious to draw by hand. If you have a computer and know how to use Excel, click on the Chart Wizard and select the pie chart once you have entered your data on a spreadsheet and the pie chart will be drawn for you almost instantaneously.

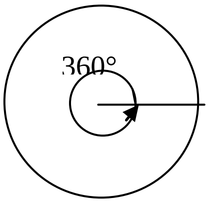
There are two main steps in drawing a pie graph by hand.

**Steps in drawing a pie chart by hand**

1 Calculating the angle in the centre. This is relatively straightforward if you remember that there are 360° around a circle.

2 Drawing the slices of the pie.

For this you need a protractor.




To find the angle in the centre:

Find the total amount to be shown - i.e. add up the frequencies.

This total represents the whole circle – i.e. 360°. So each part is a fraction or percentage of 360°

Let's look at an example to illustrate this. Suppose you did a simple count of the colour of the eyes of the learners in your class.

The table below shows this:

| Colour | Number |
|---|---|
| Brown | 32 |
| Grey | 6 |
| Blue | 22 |
| **Total** | **60** |

### Look at brown eyes:

32 out of 60 learners have brown eyes;

the fraction of learners with brown eyes is $\frac{32}{60}$;

so the fraction of the circle for brown eyes must be $\frac{32}{60}$;

so the angle of the slice for brown eyes must be $\frac{32}{60}$ x 360° = 192°;

Work out the angles for blue and grey eyes:

Angle for blue = $\frac{22}{60}$ x 360° = …………………

Angle for grey = $\frac{6}{60}$ x 360° = …………………

**Check that the total of the angles is 360°**

### Exercise 3

1 Copy and complete this pie chart to represent the data about eye colour given above.

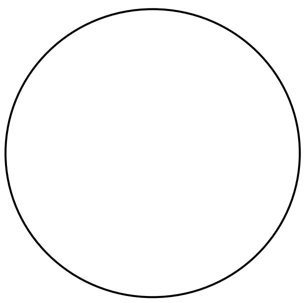
2 Draw a radius in the circle. This is where you start measuring the angles.

3 Measure the angles at the centre.

4 Give a title and a key for the pie chart.

5 Use Excel to draw the pie chart if you are able to.

6 Compare your hand drawn graph with the computer generated graph if possible.

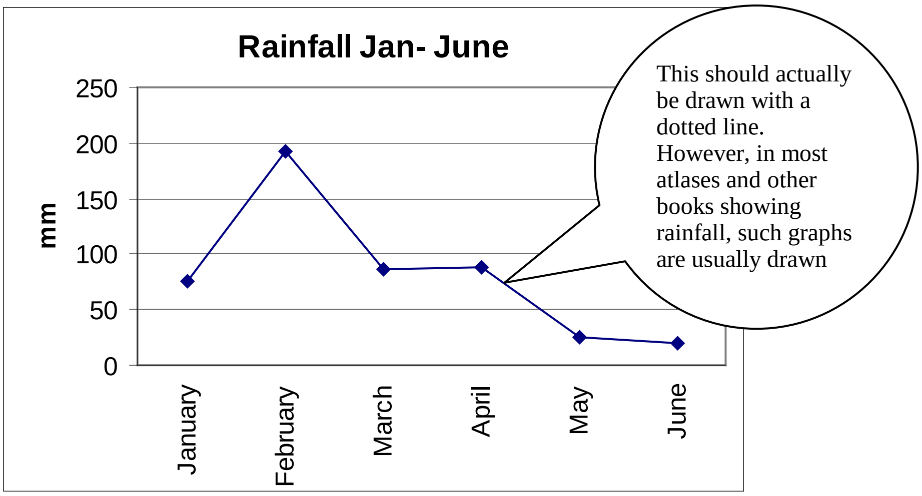


## Line graphs and broken line graphs

You can replace a bar graph by a line graph if the data on the horizontal axis is continuous such as time, temperature or age. In this case the data is plotted as a series of points that are joined by straight lines. Businesses often use line graphs to show information about profits or periods of production. Geographers use line graphs to show monthly rainfall or crop yields over time.

Line graphs are useful as they show trends and can easily be extended. This means that with some line graphs it might be possible to continue the line to show what might happen in the future.

The line graph below shows rainfall measured over a period of 6 months.



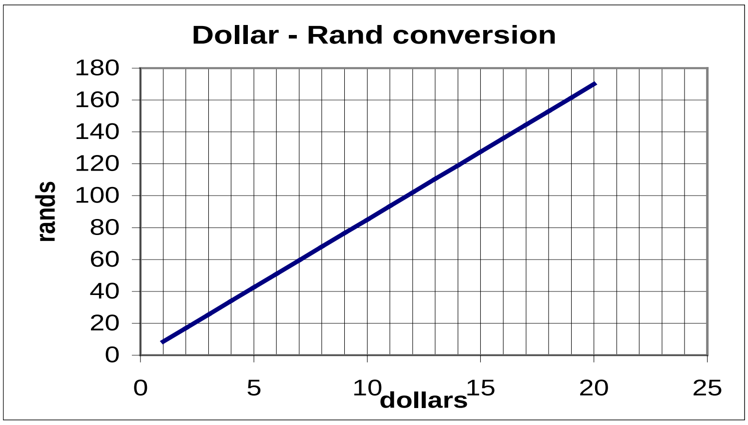

Look at the graph carefully.

i Which month has the most rainfall?

ii Which month has the least rainfall?

NB: The line graph above shows the rainfall at a certain place. Because the points are joined it suggests that the rainfall changes as shown by the lines. This is not so. You are just joining isolated rainfall readings. A line graph like this is sometimes called a broken line graph.

Line graphs can also be drawn for conversions – i.e. a change from one unit of measure to another.




Conversion graphs can be used to change from metric to imperial units and vice versa or from one currency to another.

Notice in the line graph above that the scale on the two axes is different. The vertical axis goes up in twenties, the horizontal axis goes up in fives.

In the following exercises, you will represent data in the four ways shown in this chapter – pictogram, bar graph, pie chart and line graph.

## Exercise 4 a

Thembi kept a record of the hours she spent on different activities during the day. This information is shown below.

1 Complete the table to show the degrees needed for each activity when drawing a pie chart.

2 Draw the pie chart.

3 Represent the information using a line graph.

| Activity | Number of hours | Number of degrees |
|---|---|---|
| School | 5 | …… x 360° = …… |
| Meals | 1 | |
| Homework | 3 | |
| TV | 2 | |
| Travel | 1 | |
| Sleep | 8 | |
| Other | 4 | |
| **Total** | **24** | |

### Exercise 4 b

Joe did a survey of the colours of cars parked at the local sports club. The observation sheet is given below.

1 Complete the frequency table.

2 Display the data as a pictogram, a bar graph and a pie chart.

3 Which representation do you think is best? Explain your response.

| Joe's observation sheet | | |
|---|---|---|
| **Colours** | **Tallies** | **Frequency** |
| Red | 卌 卌 | |
| Blue | \|\| | |
| Green | 卌 卌 卌 | |
| Black | 卌 | |
| Orange | 卌 卌 \|\| | |

# Interpreting data

You have read about some ways to collect, organise and present information or data. Remember that the whole point of collecting data is to help you understand more about the world you live in. Information can be collected through questionnaires or surveys that ask people questions about their lives. You can develop questionnaires if you want to find out what different people think about products or opinions or aspects of life. You can do surveys if you want to know people's opinions about things. A government will conduct a census if it wants to know how many people live in a place, who they are, what they do, how big their families are, where they live etc. Now we will look at what the representations of the data you have collected can tell us about our world.

You have seen that drawing graphs or pie charts helps give a picture of data collected. Rather than having long lists of numbers or facts, a graph can help you understand the data. Now we look at how to interpret the graphs you drew to illustrate the data; how to analyse and draw conclusions about the data, how to answer the questions you asked in your survey or questionnaire.

When interpreting data it is a good idea to discuss your interpretation with the other members of your study group. You may 'see' things that the others do not. By sharing your ideas you can get a fuller idea of what the data is saying. It is a well-known fact that statistics can be misleading.

They are often used to prove a point, and can easily be twisted in favour of that point!

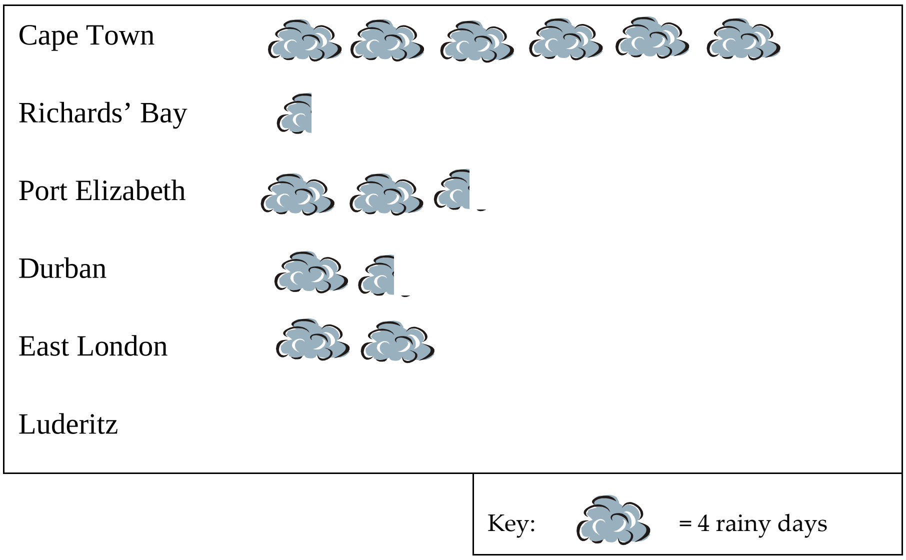
Data displayed in graphs and on bar and pie charts can sometimes be distorted to give false impressions. It is important to look very carefully at the graphs and diagrams so that the visual aspects of the charts, graphs and diagrams do not deceive you. The way you interpret the data usually depends on the reason for collecting it. Your initial question or hypothesis is important in determining the emphasis of your interpretation.

When analysing data you can make general conclusions: more people like chocolate ice cream; and/or mathematical conclusions: the mean of the marks is 54%. Again your initial question or hypothesis will determine your approach.

## Interpreting pictograms

Remember that a pictogram shows data as little symbols or pictures. A pictogram gives you a quick impression of the information. You must always look at the key to see how many items of data the symbol or picture represents. Part of a picture or symbol represents a fraction of the number of items.

The pictogram below shows the number of rainy days during the month of June at six towns on the coast of South Africa. You can immediately see which town had the most rainy days and which town had the least. If you look at the key you can tell that Richards Bay had 2 rainy days, Port Elizabeth had 10 rainy days and Luderitz had none.

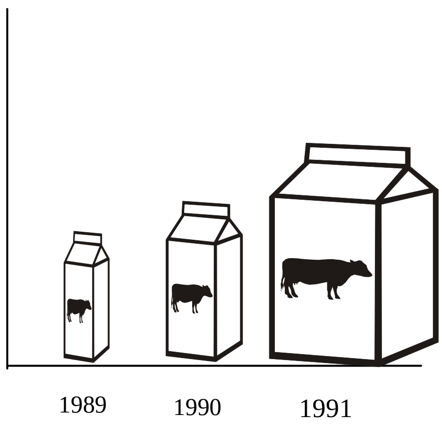


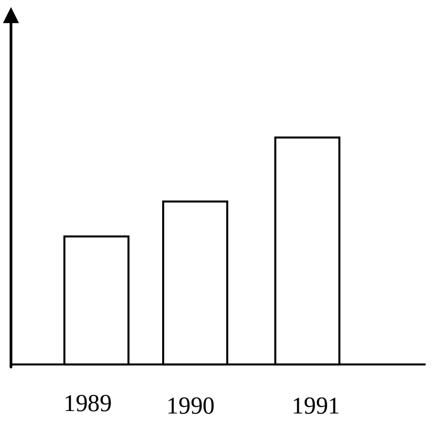

## Misleading pictograms

Sometimes pictograms are designed especially to give misleading information. Sometimes pictograms are drawn badly and the information that they portray is misleading. You must be aware of this when drawing your own pictograms and when making interpretations from pictograms in magazines and newspapers.

The ambiguity arises when symbols are incorrectly drawn or when spacing is unequal. Sometimes this is intentional – specifically to give information that is unclear – and sometimes it results from poorly set out work. Look at the examples below:

The two diagrams show information about the sales in a milk depot during 3 consecutive years. The first diagram is a pictogram with milk cartons used to show the sales of milk. The second is a bar graph showing the sales of milk. Which diagram do you think shows misleading data?



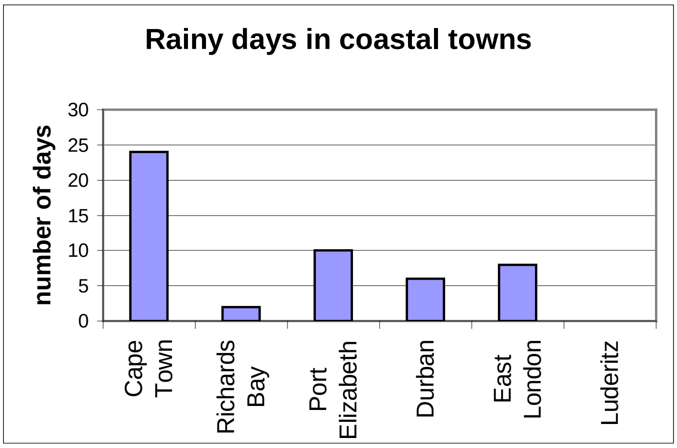




## Interpreting bar graphs

In the same way that pictograms are easy to read, bar graphs are also very easy to read. The lengths of the bars stand for the size of the data. Important points to look for when reading information off a bar graph are:

- The title – what is the bar graph about?
- The axes – check the labels of the axes. One axis gives the labels of the bars, the other tells you how many items in each bar.
- The scale – the scale on the number axis tells you how many. You might have to work out how many items are between numbers shown on the axes.

The data about the rainy days in coastal towns on the previous page could have been shown in a bar graph like this:




With the scale as shown you need to judge whether Cape Town has 23 or 24 rainy days.

However, it is easy to compare the number of rainy days at the different towns. It is easy to see that Cape Town has the most rainy days and that Luderitz has the least.

## Misleading bar graphs

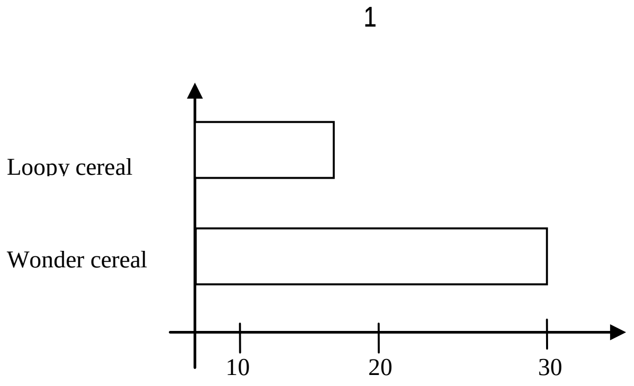
Bar graphs can also be misleading. An important thing to look at is the scale on the axes:

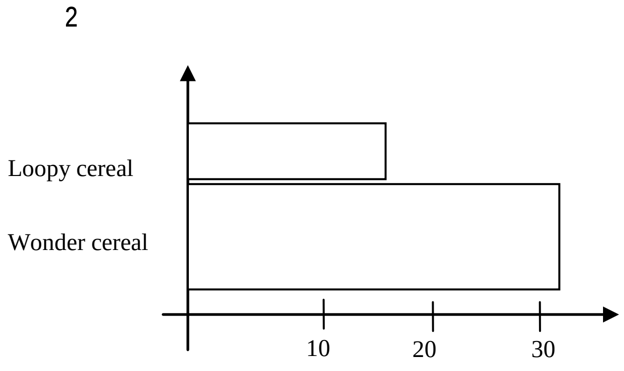
- Does the scale start at zero
- Is the scale distorted – too squashed up or too spread out. This is a trick that some companies use to enhance the look of their sales.

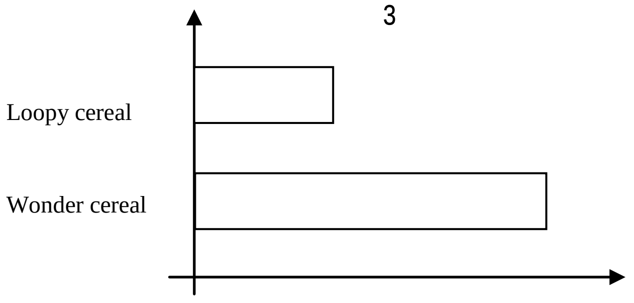
Also check the width of the bars. These can be distorted as in the milk cartons on the pictogram.

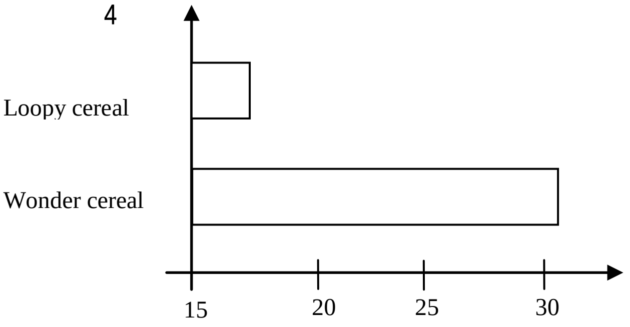
The bar charts on the next page show a comparison between two different brands of cereal.

A company that wants to show that Wonder Cereal is better than Loopy Cereal could use any of these bar graphs. They all show misleading information. Look at them carefully to see the different ways in which they are misleading.



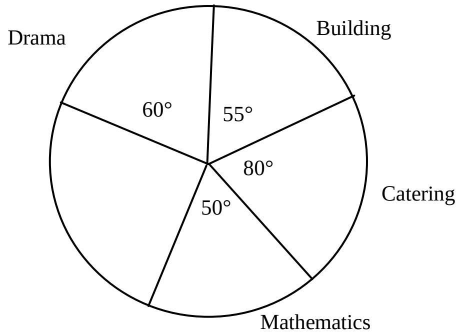




## Interpreting pie charts

The interpretation of pie chart is based on the fact that the largest ‘slice of pie’ relates to the largest item of data and the smallest ‘slice’ to the smallest item. It is therefore easy to make comparisons between the relative sizes of data items.

Sometimes the size of the respective slices is easy to estimate by eye. 90° at the centre of a circle is a quarter of a circle. Sometimes it is not so easy to see the relative slices of the sizes of the pie. This could be frustrating if you want to make comparisons.



The pie chart shows the number of learners in different sections of a college. 220 learners are in the building department. How many learners are taking mathematics?

You know that 55 ° represents 220 learners.

You can work out that 1° represents $\frac{220}{55}$ = ……….learners.

And that 50° represents 50 x ………. learners

So the mathematics department has …………learners.

If badly drawn, pie charts can also display misleading information. Remember that one of the main advantages of pie charts is that you can see part of the data as a fraction of the whole data.

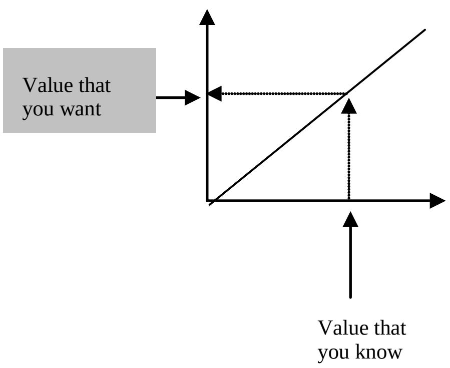
## Interpreting line graphs

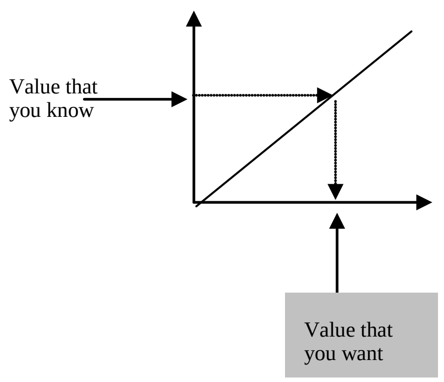
Line graphs are an important feature of much of mathematics. You might have looked at some straight-line graphs with the learners in your class. Line graphs are most often used for representing continuous data.

Some important things to help you interpret line graphs are:

- The title – what is the line graph about?
- The axes – check the labels of the axes.
- The scales on the axes – do the scales start at zero? What else do the scales tell you?

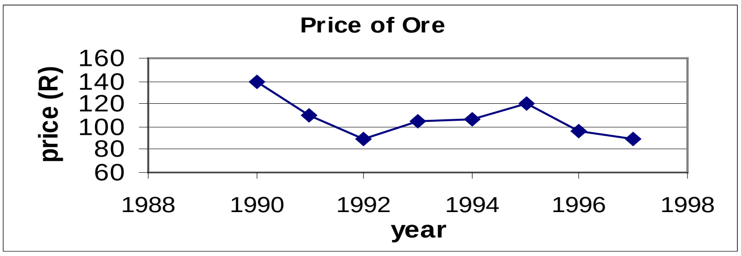
Reading a line graph that illustrates data is like reading any other sort of straight-line graph. Look carefully at the labels of the axes and then read off the values.

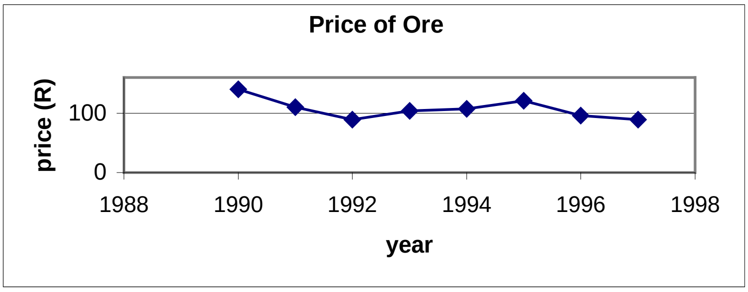


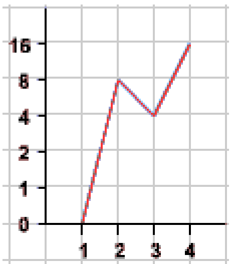
## Misleading line graphs

Some line graphs are purposely drawn to convey misleading information. Look carefully at the two graphs below. They both show the same information but the 'look' of each is completely different because the scales are different. They appear to tell a different story.

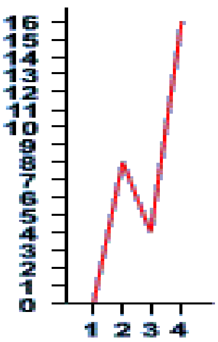



Look at this graph:




Although the vertical scale starts at 0, it does not go up in even steps. This has the effect of distorting the graph, and making it look as though the biggest jump is between 1 and 2 rather than 3 and 4. Also, there are no labels on the axes. We have no idea what this graph represents!




Here is the same graph with a correct vertical scale.

Does it tell the same story?

In what way is it the same?

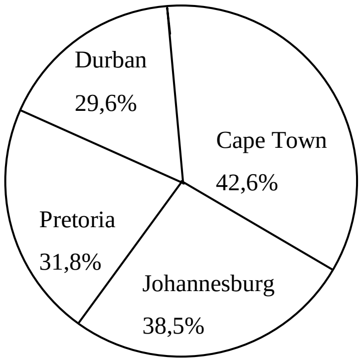
In what way is it different?

Graphs taken from:

http://www.bbc.co.uk/schools/gcsebitesize/mathematics/datahandlingfi/representingdatarev5.shtml

## Exercise 5

Below are a graph and a newspaper article taken from The Star newspaper (1999) about impulse buying. Read the article carefully. Think about things like the assumptions that are made by the writer/researcher and whether the article and the graph tell the same story.




### Who are the impulse buyers?

South Africa is a nation of shoppers with increasing numbers defined as impulse buyers who respond to glossy adverts and come-ons such as ‘never to be beaten bargains’ and ‘buy one and get one free’.

This, in part, has emerged from one of the most comprehensive surveys of consumer shopping behaviour which has just been compiled by Media & Marketing Research (MMR).

MMR’s research provides answers to a host of questions about South Africa and how its people buy.

Capetonians were the most likely to respond to bargains, good buys as well as advertising come-ons on TV and in newspapers (42,6%). Johannesburg shoppers came in second at 38,5%, Pretoria notched up 31,8% and Durbanites were rated at 29,6%.

The ranks of impulse shoppers were most likely to come from these ‘bargain hunting’ groups.

1 What is wrong with the pie graph?

2 Who do you think ‘impulse buyers’ are?

3 Who do you think ‘bargain hunter’ shoppers are?

4 Redraw the given data in a more suitable and correct graph.

5 According to the researchers, what does the given data represent?

6 What does the newspaper headline suggest the data represents?

7 What assumptions are made about the meaning of results of research on ‘bargain-hunting’ shoppers?

8 What does the data not tell us about impulse buying?