Minibooster 4: Progressing to level 6 and beyond

Making sense of graphical data

Background

The following points need to be made explicit to pupils.

- **What a graph is for** – as a way of presenting and reporting data. A graph can also help us determine if there are any changes in a variable over a period of time. A graph can be seen as a story board, but using shape instead of words to tell us what is happening.
- **Why a graph is used and not just tabulated data** – It is often easier to see patterns and trends in data when you plot a graph. By drawing the graph you can find unknown data and predict what happens next. You can also decide if you have enough evidence to answer a question or make a judgement.

A pupil working at:

Level 4

- records their observations, comparisons and measurements using tables and bar charts and begins to plot points to form simple graphs;
- recognises that the presentation of experimental results through the routine use of tables, bar charts and simple graphs makes it easier to see patterns and trends.

Level 5

- uses line graphs to present data, interpret numerical data and draw conclusions from them;
- describes ways in which the presentation of experimental results through the routine use of tables, charts and line graphs makes it easier to see patterns and trends;
- explains patterns and trends in results and how this supports or negates any prediction made;
- recognises that the selection, ordering or rejection of secondary data could lead to different conclusions.

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Level 6

- records data and features effectively, choosing scales for graphs and diagrams;
- analyses findings to draw conclusions that are consistent with the evidence, and uses scientific knowledge and understanding to explain them and account for any inconsistencies in the evidence;
- manipulates numerical data to make valid comparisons and draw valid conclusions;
- communicates qualitative and quantitative data effectively, using scientific conventions and terminology;
- plots line graphs using more complex scales;
- explains the relationship between the dependent and independent variables;
- identifies and explains anomalous results;
- is able to read simple negative scales;
- uses and applies qualitative and quantitative methods to obtain and record sufficient data systematically;
- explains how the presentation of experimental results through the use of tables, charts and line graphs makes it easier to see patterns and trends.

Level 7

- records data in graphs, using lines of best fit;
- can extrapolate and interpolate with justification;
- uses quantitative relationships between variables;
- explains how the numerical data has been manipulated to make valid comparisons and conclusions linked to the original scientific question;
- produces a detailed conclusion consistent with the graphical evidence;
- plots two sets of data on the same pair of axes;
- uses proportional relationships such as doubling one variable halves the other;
- knows when and when not to use a line of best fit.

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To move pupils from level 4 to level 5

1. Ensure pupils know which axis represents which factor/variable.
2. Encourage pupils to use the vocabulary of graphs: axis, horizontal, vertical, origin, line and bar.
3. Ensure pupils can read a graph; demonstrate ways to describe what a graph is showing: increase, decrease, no change.
4. Demonstrate how to construct a suitable scale for a given set of data.
5. Illustrate how to break up a graph into discrete sections, read each section independently, and then sequence the sections to build up the whole story. (Start with two-section graphs, then move onto three and so on.) Emphasise that line graphs have to be read from left to right in order to make deductions, whereas this is not necessarily important with a bar chart.

To move pupils from level 5 to level 6+

1. Ensure pupils understand what a point on a graph means.
2. Demonstrate how to sequence a description or explanation of a two- or three-part graph.
3. Support pupils to decide what type of graph to use.
4. Demonstrate how a graph can change by using a different range of data.
5. Show how to sketch a graph from a description of results.
6. Show pupils how to sketch a graph of their prediction.
7. Give pupils more practice at constructing and interpreting a range of complex graphs.
8. Use the strategy of living graphs to develop an understanding of what a graph is showing and how pupils' understanding of models can be linked to it.
9. Demonstrate how to decide whether a line of best fit is needed and how to decide where to draw it.
10. Make sure pupils can explain how the presentation of experimental results through the routine use of tables, charts and line graphs makes it easier to see patterns and trends

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Activities

These are adapted from Minibooster 4: *Making sense of graphical data – Science intervention materials* DfES 0077 2004.

1. Use Worksheet 4(i) '*What does the line mean?*' Ask pupils to think of an activity relating to the graphs (e.g. what relationship produces the specific graph). Pupils add the independent and dependent variables.

2. Use Worksheets 4(ii) '*Tell the story of the line*'*.* Ask pupils to decide on suitable units and scale. Ask pupils to consider whether the line would still be the same if different scales were used. Could any of these graphs have negative numbers in the scale? Ask pupils to explain the science behind the graphs.

3. Use Worksheet 4(iii) '*Two- and three-part story'*. Ask pupils to work in small groups to discuss possible scenarios that could produce these graphs. Then ask pupils to decide on suitable variables and scales for each graph. Ask groups to swap and to assess another group's work.

4. Make A3 copies of the diagram and graph from the 2004 Key Stage 3 tests (Paper 1: Tier 3–6, question 15, or Tier 5–7, question 6) showing what happens to stearic acid as it is heated. Ask pupils to place the cards from Worksheet 4(iv) '*Cards for stearic acid graph activity*'at appropriate points on the graph and to explain why each statement applies to that part of the graph.

5. Use graphs from past papers, textbooks, AKSIS and pupils' work to consider:
    - whether it needs a line of best fit and how to decide;
    - whether the line of best fit (if it is drawn) is the correct one;
    - what the points on the graph represent (see pages 66–71 in AKSIS *Getting to grips with graphs*, available from the ASE ISBN 086-357-3029);
    - whether the graph line should go through the origin and be able to explain why.

6. Use results tables from pupils' work or other sources. Ask pupils them to decide if the results should be shown on a graph and if so what type of graph. Use this to agree some guidelines.

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7. Present pupils with a table of results (at least ten readings) for a familiar experiment (one that does not have a simple linear correlation). Ask them to draw graphs based on the first three or four points, then the last three or four points, then use every third point. Compare these graphs to see if there are differences between these and the complete graph.

8. Ask pupils to write some predictions or to describe their results; the rest of the class sketch graphs of these. Allow small groups to compare their graphs and discuss any differences before agreeing a final version.

9. Pupils are often confused by graphs that do not yield a simple straight line. Give pupils experience in plotting and interpreting different shapes and types of graphs. Test papers, text books and the mathematics department are useful sources.

10. Give pupils experience of interpreting graphs with negative values (e.g. minus temperatures, decrease in mass of seeds during germination).

Additional information

Lines of best fit

- These:
  - do not have to be straight
  - do not join all the points
  - do not have to go through the origin.
- There could be more than one line of best fit. Pupils need to be able to choose the one that makes the most sense.
- You can sometimes see where the line might go by holding the graph at eye level. A bendy ruler or piece of card might help in producing a line of best fit.
- Check the mathematics department's policies and schemes of work to coordinate the teaching of graphs.

Plotted points

- Pupils need to understand that each point is only an approximation, not an exact point.
- Pupils need to be confident to leave out some points when they draw the line of a graph.
- Show pupils that points on a graph can be drawn as a dot with a circle round to show some of the uncertainty.

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Which type of graph?

- If both variables are continuous numbers, draw a line graph. If the independent variable is categories (words) and the dependent variable is numbers, use a bar chart.
- Pupils after confused between bar charts and histograms.
    - On a bar chart the independent variable is categoric and is stated in words.
    - On a histogram the independent variable is given in numbers but the numbers are grouped to show the pattern more clearly.

  For example, when measuring the heights of pupils in the class, these can be grouped into categories such as 140–149 cm, 150–159 cm, and so on, and displayed as a histogram.
- A scattergram or scattergraph is a type of line graph where for any independent variable value there is a range of values for the dependent variable. It does not give a straight line but a suggestion of a trend or correlation.

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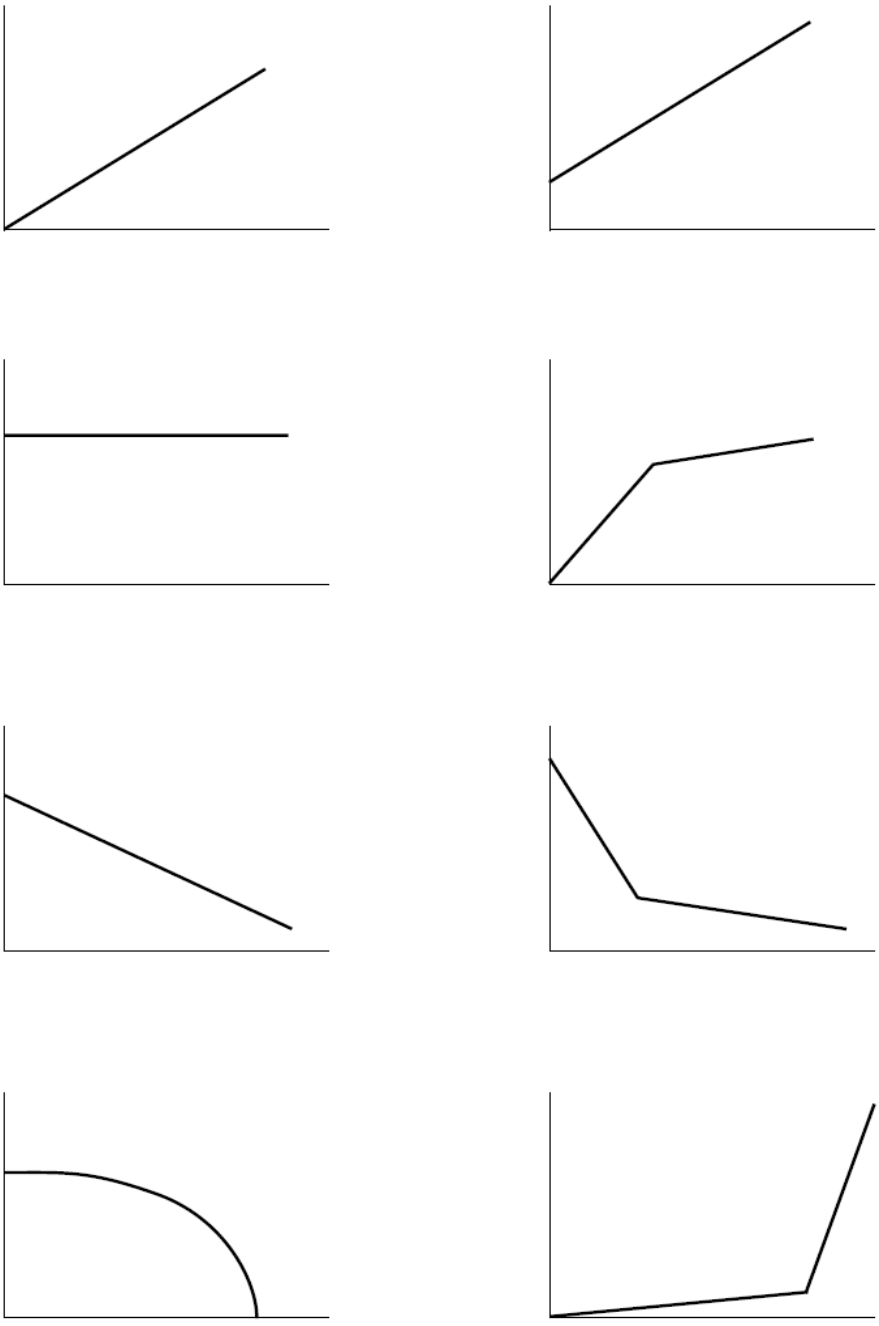
Worksheet 4(i)

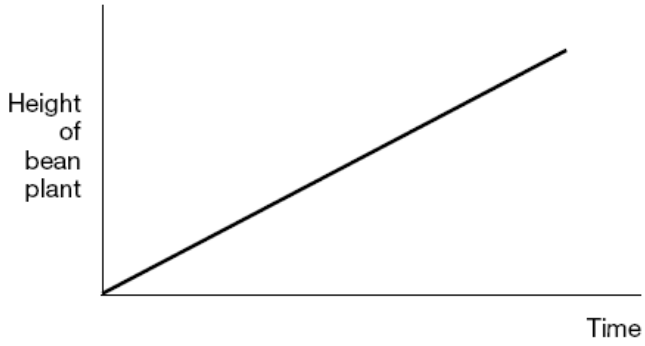
What does the line mean?



Worksheet 4(ii)

Tell the story of the line

1



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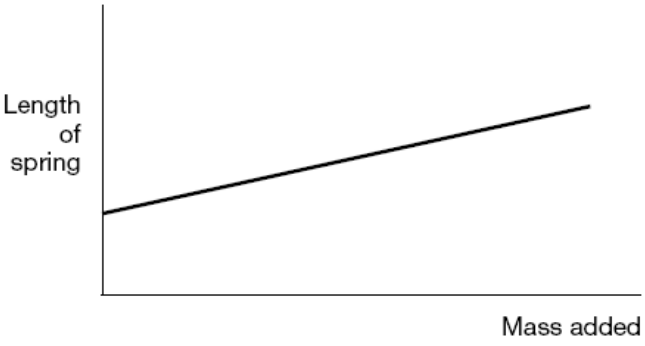

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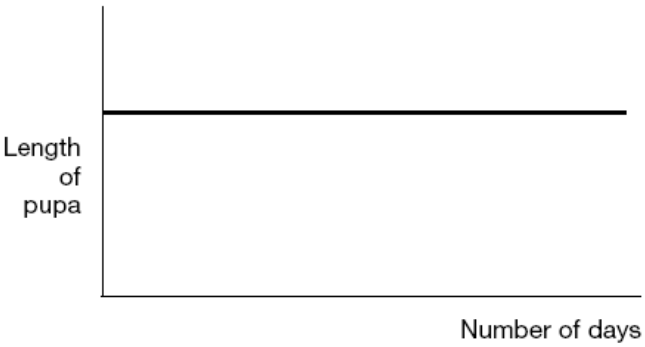

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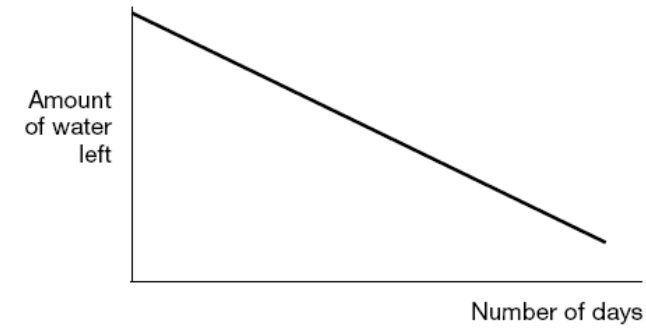

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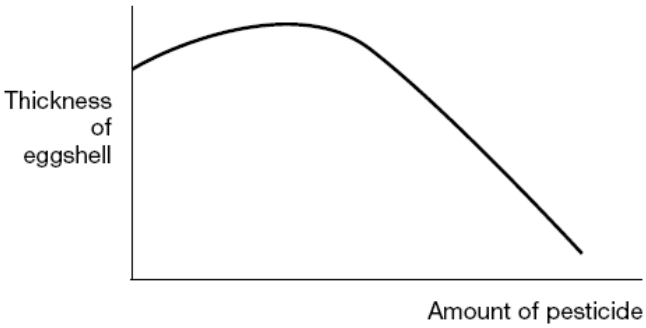

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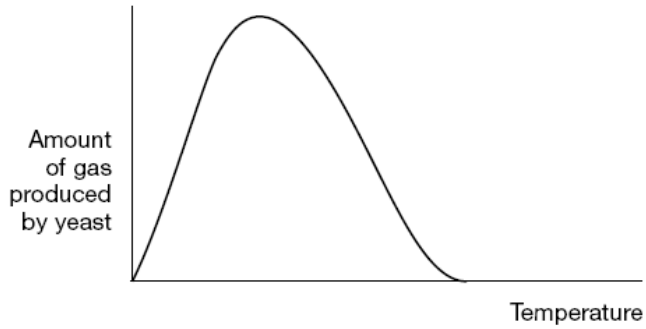

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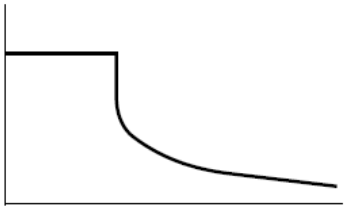
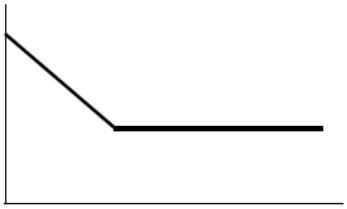
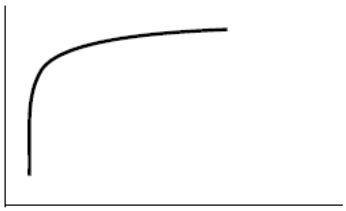
Worksheet 4(iii)

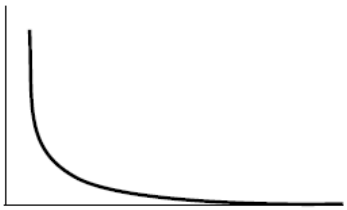
Two- and three-part stories

Two-part stories

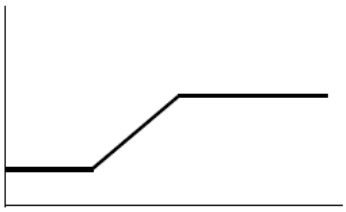


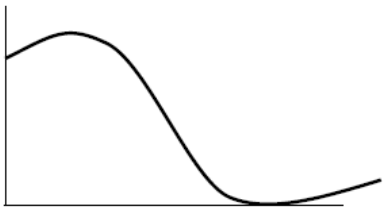


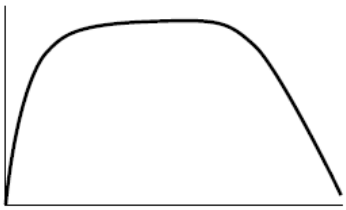


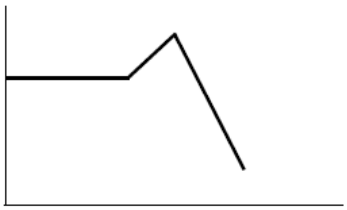


Three-part stories









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Worksheet 4(iv)

Cards for stearic acid graph activity

Cut up the cards below and use with 2004 Key Stage 3 tests, Paper 1: Tier 3–6, question 15 or Tier 5–7 question 6.

'Hey', said Balbinder, 'the data logger has broken.'	'The water is really boiling now,' said Balbinder.
The pupils switched the hotplate on and the readings on the data logger started to rise slowly.	Stearic acid boils at 360°C.
The data logger showed a steadily increasing rise in temperature.	Stearic acid is used for making soap, candles and cosmetics.
For a while there appeared to be no temperature change in the stearic acid.	As a solid is melting, the energy transferred is used to pull the particles apart.
'Look! The temperature is moving. It's going up fast now,' cried Ruth.	'I wonder why the temperature goes up more quickly when the stearic acid is liquid?' asked Ruth.
'There's been solid and liquid in the test tube for at least five minutes,' mused Ruth.	The data logger stood upright in the test tube supported by the solid stearic acid.
'Do you remember Sir saying last week that particles in a solid are packed close together?' asked Balbinder.	'Where on earth is the heat energy going if the temperature of the stearic acid isn't rising?' wondered Ruth.
As the particles in a solid are heated, they vibrate more and the temperature rises.	A soap factory with bars of scented soap was found in the ruins of Pompeii (79 AD).
When all the particles are pulled apart they are freer to move. Then as more energy is put in it makes them move even faster and raises the temperature.	All the time there is energy transfer, something is happening.
As energy is transferred the temperature rises.	

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