SCIENCE | BTEC LEVEL 2 | EDEXCEL

Teaching Pack

For BTEC First Award in Applied Science
Unit 8: Scientific Skills

BTEC Next Generation

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POD 4721

Contents

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In this matter they should also determine the nature of information or support pr the medium and style of support. So specifically, they should determine which i any, and which, if any, to provide in written format. Similarly, if the style of the s information or support itself is appropriate then the material should be so adjust example, if any of the contained material appears to overly direct the student, wh of the student's project, then the teacher should remove or adapt this material to intention to do this to achieve a certain level within the project.

In summary, it is intended that these materials be used appropriately and at the t the teacher take into consideration the ability of the individual or group. It is the the suitability of coursework/project publications and to decide which pages, if a

Safety in the classroom

It is the teacher's responsibility to ensure the safety of their students in the classr all instructions carefully and are confident in your own knowledge before carryi demonstrations suggested in this resource. If you are unsure about anything, see experiments in the classroom.

Teacher's Introduction

This unit is taught over 30 guided learning hours (GLH). Teachers will ha
balance between teaching and exam practise – this scheme of work sugges
teacher-taught hours and 16 lessons for exam practise and catch-up time f
lessons or need extra support. 'Did you know' boxes are included to give
interesting extra information about the topic – they do not need to know t

This pack contains the following materials:

1. A single-page overview scheme of work
2. 10 lesson plans
3. Notes for each lessons covering all the learning aims between them
4. Recap Questions and Exam-Style Questions in non-write-on and writ learning, with answers

This resource is designed to be flexible in the following ways:

- For each lesson there is a lesson plan followed by student notes and q repeated provided in write-on format. You could use the material in o
    1. Use the notes to support your classroom teaching and then hand questions or the write-on questions at the end of the lesson (possi
    2. Use the notes to supplement your own notes or the textbook and the lesson as a summary with the questions so students can comp notes as support.
    3. Just use the questions (either write-on or non-write-on as approp and subsequently hand out the notes at revision time.

Suggested Scheme of Work

GLH/LP	Learning Aim	Title
1	A.1 & A.2	Producing a Good Plan for an Investigation
2	A.1 & A.2	Producing a Good Plan for an Investigation (Co
3	B.1, B.4 & B.5	Tabulated Data and Calculations
4	B.6 & B.8	Drawing Graphs
5	B.9 & B.10	Obtaining Data from Graphs
6	B.2, B.3, B.7 & B.11	Identifying Anomalous Results and Explaining
7	B.12	Describing Trends and Patterns Identified in Ta
8	B.13	Analysing Evidence to Draw Conclusions
9	C.1, C.2, C.3 & C.4	Evaluating Evidence and Investigative Methods
10–14	*Practising unit content through practical investigations*	
15–30	*Opportunity for catch-up and exam practise*	

Lesson Plan Key
content provided in teaching notes

Lesson Plan 1: Producing a Good Plan for a

Learning Aims

Students should understand:

How to produce a good plan:

- identify relevant equipment and give reasons for these choices
- identify risks that are relevant to the method and describe how they assessment)
- give a suitable range and number of measurements and explain why
- outline a logically ordered method appropriate to a given hypothesi

Key words: Scientific method, planning, equipment, risk assessment

Starter

Ask students what they think a scientific investigation involves based upo activity could be carried out as a class mind map activity on the board.

Main

1. Introduce students to the idea of a scientific method.
2. Explain how you go about planning an investigation.
3. Explain equipment choices – show students examples of equipme measuring cylinders of different sizes, pipettes, etc. Ask relevant these would be most appropriate to measure out 0.5 cm^3 of acid a
4. Students should then work in pairs to write a method for a simple tas Instructions must be given using appropriate scientific terminology a
5. Go through examples with students and make suggestions for improv
6. Introduce concept of carrying out risk assessments and link back dangers?), refer to hazard symbols which students should have s examples of substances with various hazard symbols in the lab.
7. Ask students to attempt the Recap Questions in pairs.
8. Go over the answers to the Recap Questions as a class.

Plenary

True or false?

Long hair should be tied back when using Bunsen burners.	*Tru*
A risk assessment is not necessary when planning an experiment.	*Fals*
Safety goggles should be worn when using acids.	*Tru*

Planning an Investigation

Scientific Investigations

Scientific investigations all have something in common:

They start with an **observation** that leads to a **question** which you wish to discov scientific experimentation. To do this you make a **plan**; identifying the equipmen and how to reduce them, formulate a **hypothesis** (what you think will happen) a you will do. You then **perform your experiment**. After you have performed your of recorded results; you can display these in a number of ways, as a **table** or as a of a **graph**. Tables and graphs will help you to see trends and patterns in your da these in your **conclusion** – a summary of what you found out. In your conclusion hypothesis based upon the evidence you collected. Finally, end with an **evaluati** to your method or ways of extending your investigation.

The above sequence is known as the **scientific method** and in this unit you will le components in turn.

Part of investigation	What to include
Plan	Equipment choices with reasons, hypothesis, v that you will test and the ones that you will co and a risk assessment that is appropriate to th
Results and analysis	Tables of results, graphs to represent the colle pie charts, line graphs), comments on trends a in the data, identification of anomalous result
Evaluation	Evaluate the method, suggest improvements t suggest further investigations to support the h

Did you know?
***The development of the scientific method** goes back thousands of ye ancient history.*

*Its development began in **Ancient Greece** with the famous Greek philosopher **Aristotle** (born in 384 BC). Aristotle was one of the first people to recognise the importance of measurement and observation.*

*Greek knowledge was added to during the **Renaissance period** when two influential men called **Roger Bacon** (born in 1214) and **Francis Bacon** (born in 1561) also developed the idea of making observations, hypothesising and then carrying out experiments to test these hypotheses.*

*In the twentieth century, an important philosopher **Karl Popper** recog theories are not always correct and can be proven to be wrong throug **Thomas Kuhn**, also a philosopher, built on this recognising that scienc theories about how things work, but that eventually, one of these the*

What is a plan?

A plan is the outline of what you intend to do to scientifically investigate the ans
plan you should:

- Write a hypothesis.
- Identify the equipment you will need.
- Carry out a risk assessment.
- Identify variables (the things you will change or keep the same) and explain
- Write a logical method that could be followed by someone else who wants

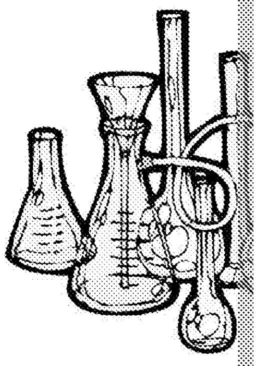
Hypothesis: *a tentative explanation for an observation that can be tested thr*
Effectively, writing a hypothesis involves using your scientific knowledge to make

Equipment

When selecting equipment for an experiment, think about what you need to me
stopwatch to measure time, a balance to measure mass, a measuring cylinder to
thermometer to measure temperature. Many of these come in different sizes an

Some common items of equipment that you might use in a scientific investigatio

- test tube
- thermometer
- stopwatch
- boiling tube
- beaker
- Bunsen burner
- measuring cylinder
- conical flask
- burette
- pipette
- Petri dish



You need to **select equipment that is relevant to your needs**. For example, don't
cylinder if you only need to measure 10 cm^3 of liquid! Also choose equipment th
amount of precision for your needs. For example, to ensure mass readings are ac
balance that measures to two decimal places rather than one decimal place. This
measuring small quantities.

Your results will be more accurate if you use the most appropriate equipment. W
you should justify your choices with reasons.

Example

> *"I chose to use a thermometer that measures temperatures between*
> *measuring body temperature. Body temperature is approximately a*
> *Anything significantly higher or lower than this value results in dea*
> *thermometer only needs to measure a small range of values".*

Risk Assessment

A risk assessment is an assessment of the potential risks and hazards involved in an experiment and a description of how to manage them. In order to write a risk assessment you must first identify a potential hazard (something that may cause harm), identify the potential harm this hazard could cause and explain how you plan to reduce and control the risk presented by this hazard.

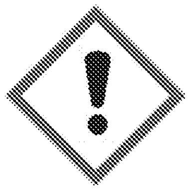
The risk assessment should be relevant to your method.

For example, a risk assessment for using a Bunsen burner would identify that it p goggles should be worn, long hair should be tied up and contact with flammable s

More examples of some general health and safety issues in the lab are listed belo

- Keep your workspace tidy.
- Do not eat any food or drink any drink whilst in the laboratory.
- Wear safety goggles when appropriate.

In Unit 1 you studied **hazard symbols** which you might find on items in the labora of them:

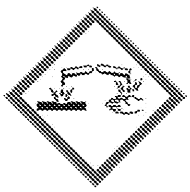


CAUTION – HARMFUL AND IRRITANT

The 'caution' symbol indicates that a substance is either **harm**

Harmful substances may be damaging to health if swallowed, b the skin. When handling harmful substances eye protection sh only be used in well ventilated labs or fume cupboards. If the s with the skin it should be washed off immediately and any spil immediately.
Example: copper(II) sulphate

Irritant substances can cause reddening or blistering of the skin handling them and if they come into contact with the skin, wa clear up any spillages immediately.
Example: dilute sodium hydroxide solution



CORROSIVE

Corrosive substances destroy living tissues on contact. Avoid s goggles (eye protection) and gloves (skin protection). If a corro wash it off immediately. Clear up spillages immediately.
Example: hydrochloric acid

HIGHLY FLAMMABLE

Substances that catch fire easily. They should be kept away fro protection and clear up any spillages.
Example: ethanol

You should also consider less obvious hazards for example some **microorganisms** might use in biological investigations can be dangerous as they can cause disease should also be taken when carrying out experiments using **electricity** in Physics.

Recap Questions – Planning

1. Arrange the following components of the scientific method in the corr
    - evaluation
    - perform experiment
    - present data
    - plan
    - conclusion
    - question

2. What is a hypothesis?

3. Sally wants to measure 20cm^3 of acid. What sized measuring cylinder
10 cm^3, 25 cm^3 or 50 cm^3?

4. Describe what a risk assessment is.

5. How can risks be reduced in the lab?

6. Think about a practical you have carried out during your BTEC course
What did you do to control the risks?

Recap Questions – Planning

1. Arrange the following components of the scientific method in the corr

   - evaluation
   - present data
   - conclusion
   - perform experin
   - plan
   - question

   1. .... 2. ....
   3. .... 4. ....
   5. .... 6. ....

2. What is a hypothesis?

   ....

   ....

3. Sally wants to measure 20cm^3 of acid. What sized measuring cylinder correct size from the options given below.

   ☐ **10 cm^3**
   ☐ **25 cm^3**
   ☐ **50 cm^3**

4. Describe what a risk assessment is.

   ....

   ....

5. How can risks be reduced in the lab?

   ....

   ....

6. Think about a practical you have carried out during your BTEC cours What did you do to control the risks?

   ....

   ....

   ....

   ....

Lesson Plan 2: Producing a Good Plan for a[n]… (Continued)

Learning Aims

Students should understand:
How to produce a good plan:
- identify relevant equipment and give reasons for these choices
- identify risks that are relevant to the method and describe how they … assessment)
- identify appropriate variables (dependent and independent) and de… controlled
- give a suitable range and number of measurements and explain why
- outline a logically ordered method appropriate to a given hypothesi…

How to provide a hypothesis based on relevant scientific ideas, which is … where appropriate.

Key words: planning, variables, independent variable, dependent variabl… methods

Starter
Ask students to match the following hazards with their definitions: **corros… flammable**

a) catches fire easily
b) destroys living tissue on contact
c) damaging to health if swallowed, breathed in or absorbed throug…
d) causes reddening and blistering of the skin

Answers: a) flammable b) corrosive c) harmful d) irritant

Main
1. Introduce the concept of variables. Explain what independent an… explain their significance in ensuring experiment is a fair test. Go…
2. Talk through the numbers and range of measurements that shoul…
3. Reaffirm the importance of writing a logical method so that resul… somebody else using the same method.
4. Ask students to answer the Exam-Style Questions.
5. Go over the answers to the Exam-Style Questions as a class.

Plenary
Ask students to write down a definition for the following terms:
- independent variable
- dependent variable

Variables, Measurements and Hypo

Variables

Variables are the things we investigate in our experiments. We can choose which which ones we keep the same and observe the effects of these changes.

Independent variable	*The variable we change to observe its effects.*
Dependent variable	*The variable we measure for each change in the inde*
Control variables	*Variables that could affect the results that must be k*

When trying to work out the independent variable, ask yourself the question 'W independent.

Once variables have been decided upon, everything else should be controlled to **fair test** for comparison. Sometimes it is not possible to control the other variabl of the room, but these variables should be monitored just in case they change ar

Example

Bill is investigating the amount of energy in different food samples. To do th the samples underneath a boiling tube of water and then measuring the tem water. The temperature change in the water indicates how much energy is in sample.

In this experiment the **independent** variable is the food sample, the **depend** the temperature of the water

Bill also needs to ensure that the volume of the water in the boiling tube is th should monitor the mass of his food samples.

Choosing a Suitable Range and Number of Measurements

In your method you should comment on how many measurements you intend to should also explain your choices.

The range over which you take measurements must be suitable for the independ change in the dependent variable.

Repeating your experiment a number of times will enable you to see random err (results that don't fit the pattern) more easily. Anomalous results will be discusse

Logically Ordered Methods

It is important that your method follows a logical order that makes sense, and th wanted to repeat the experiment again to try to obtain the same results. This is k

On a wider scale, in the science industry it is very important that experimental m across different laboratories to ensure that everyone reaches the same conclusio **reproducibility**.

Your method should be designed in such a way that it will produce valid results. V the changes brought about in the dependent variable are caused by the indepen method should take into account other variables that may affect results and exp

Writing a Hypothesis

A hypothesis is a potential explanation for an observation that can be tested thro Effectively, writing a hypothesis involves using your scientific knowledge to make be based upon relevant scientific ideas.

A hypothesis should be worded in such a way that allows it to be tested. If you w in terms of a testable hypothesis, then it is possible to use scientific method to o you choose must be appropriate for the hypothesis.

Hypotheses can be quantitative (concerning data that can be measured, e.g. leng qualitative (concerning data that cannot be measured, only described/observed, hypothesis should mention both the independent and dependent variables and b reason.

Example

> *"If I water one plant more than another, it will grow larger than th require water for growth."*
>
> In this simple example the independent variable is the amount of water the p dependent variable is the size of the plant.

Exam-Style Questions – Planning

1. Write a plan for an experiment to investigate how light affects the rate be done by shining a lamp on a beaker containing water and a water p of oxygen bubbles given off. The equipment you have is as follows:
   - lamp
   - oxygenating pond plant
   - beaker
   - metre rule
   - stopwatch
   - water

   In your plan you should include details of:
   - the hypothesis
   - the independent and dependent variables
   - what you would measure as you carry out the investigation
   - the number and range of measurements you would take

2. Ben is investigating how much acid is required to neutralise a base. He this by adding drops of the acid to a conical flask containing the base and a colour indicator. When the colour of the solution in the conical f changes, he knows that the base has been neutralised. Acids and bases potentially dangerous chemicals and the chemical bottles are labelled caution symbols. The base Ben uses is ammonium hydroxide – this is a substance that can cause a burning sensation in the nose if breathed i

   Write a risk assessment for Ben's experiment.

Exam-Style Questions – Planning

1. Write a plan for an experiment to investigate how light affects the rate be done by shining a lamp on a beaker containing water and a water of oxygen bubbles given off. The equipment you have is as follows:

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   - stopwatch
   - water

   In your plan you should include details of:

   - the hypothesis
   - the independent and dependent variables
   - what you would measure as you carry out the investigation
   - the number and range of measurements you would take

   ....

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   Write a risk assessment for Ben's experiment.

   ....

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Lesson Plan 3: Tabulated Data and Ca

Learning Aims

Students should understand:

How to tabulate data in a clear, logical way:

- with appropriately headed columns
- with units
- in ascending order of independent variables

How to carry out calculations from tabulated data:

- calculating averages
- excluding anomalous results where appropriate
- calculations using given equations

How to demonstrate appropriate use of significant figures and applicati
accuracy to which a result can be used.

Key words: drawing appropriate tables, units, significant figures calculati

Starter

Ask students to arrange the following data in ascending order: 150, 172, 16
Answer: 150, 152, 153, 157, 160, 163, 164, 172

Main

1. Go over the starter exercise.
2. Explain how to draw tables: appropriate column headings, units
order of independent variable.
3. Revision of units: ask students to think of other units that have n
information sheet.
4. Go over concept of significant figures. Attempt some examples o
5. Go over how to calculate the mean and explain the importance o
results before calculating means.
6. Explain that data in tables can be used to carry out useful calcula
7. Ask students to attempt the Questions in the pack.
8. Go over the answers to the Questions.

Plenary

Quick Quiz

- Give an example of a unit used when measuring mass *Poss*
- Give an example of a unit used when measuring temperature *Poss*
- Give an example of a unit used when measuring length *Poss*

Tabulating Data

When you collect data during an experiment it should be organised in the form o
table before you start performing an experiment. Tables can then be used to pre
graph. Graphs help trends and patterns in results to be identified and these can b
conclusion when you write about what you found out and decide if your evidenc

Tables should have **columns with appropriate headings** and should include the u
cm, m, °C. The values of the **independent variable** should be arranged in **ascend**
highest).

You might need to include an extra column for calculations (e.g. calculating a cha
have recorded the start temperature and the end temperature). Also remember
repetitions of experiments.

Units

If you don't include units in your answers to calculations, headings of tables, or axes labels on graphs, you will lose valuable marks. Some important units of measurement that you may come across in your science studies are listed in the table on the right. Can you think of any other units that you've met in your studies that aren't listed here?

Unit	Ab
gram	
metre	
centimetre	
kelvin	
degree Celsius	
second	

Example

Here is a table of results from an experiment investigating the amount of en
was carried out by burning samples of bread and pasta underneath a boili
transferred to the water was measured by measuring the temperature chan

Food sample	Temperature (°C)		
	Before	After	Change
Bread	20	36	16
Pasta	20	50	30

Columns with appropriate headings *Extra co*

Including repetitions in your results can make drawing results tables a bit mo
example above, but for three repetitions of each experiment, the table of re
would look something like this:

Food sample	Repeat	Temperature (°C)		
		Before	After	Change
Bread	1			
	2			
	3			
Pasta	1			
	2			
	3			

Note: adding repeats means we must add an average column too. When we s
mean (i.e. add up all the numbers, find the total and divide by the number of r
more detail later.

Calculations

Significant Figures

A significant figure is the first non-zero digit in a number when you read it from l

Zero counts as a significant figure if it occurs after the first significant figure.

Remember when rounding: a value of 4 or less means nothing changes, a value o significant figure by a value of 1 (e.g. 1.4 is rounded to 1 and 1.5 is rounded to 2).

The more significant figures you consider, the more accurate or precise your calc choosing an appropriate number of significant figures, consider how accurate yo

Example 1

Round <u>48</u>.3 to two significant figures

Answer: 48

Here the first significant figure is 4 and the second is 8. When considering r the number next to the second significant figure. In this case '3' is lower than our answer is 48.

Example 2

Round <u>448</u> to two significant figures

2 significant figures

8 is higher than 5 so we round up the value to 45

Answer: 450

Calculations Using Data from Tables and Given Equations

This table is the same as the table you saw previously, but now has an extra colu sample (bread or pasta). With this piece of information and the equation below, amount of energy in each food sample using the data from the table.

Food sample	Mass of sample (g)	Temperature (°C)		
		Start	End	C
Bread	5	20	36	
Pasta	5	20	50	

$$\text{Energy in food (kcal)} = \frac{\text{mass of water (g)} \times \text{temperatu}}{\text{mass of food sample (g)} \times}$$

The mass of water used each time was 100g and the food samples had a mass of

Example: calculating the amount of energy in the bread san

$$\text{Energy in bread(kcal)} = \frac{\text{mass of water (g)} \times \text{temp rise (°C)}}{\text{mass of food sample (g)} \times 1{,}000} = \frac{100\text{ g} \times}{5\text{ g} \times}$$

In the exam you will be given data in tables and asked to calculate values using g example above.

Averages and Equations

Average	*A typical value for a set of numbers*
Mean	*A type of average calculated by adding a set of values together a number of values there are*
Range	*The numerical difference between the highest value and the low*

Example of calculating the mean (average) of a set of values

Height (cm)
164
163
162
170
156
175
180
176
169
167

This table shows the heights of 10 BTEC students. To calcu of the students we add up all the values and then divide there are, in this case 10

$$\text{Mean} = \frac{164 + 163 + 162 + 170 + 156 + 175 + 180 + 176 + 169 + 16}{10}$$

$$\text{Mean} = \frac{1682}{10}$$

Mean = 168.2 cm

When using a calculator it is very important that you press 'equals' before you
So you press:

[164][+][163][+][162][+][170][+][156][+][175][+][180][+][176][+][16

To make sure the results are not changed by an anomalous result these should b calculated.

Recap Questions – Tabulated Data and Calculations

1. Put these data in an appropriate table. Time is measured in seconds a
   0 s, 0 m/s 1 s, 10 m/s 2 s, 20 m/s 3 s, 30 m/s 4 s, 40 m/s 5 s,

2. Calculate the mean of the following sets of data to one decimal place.
   a) 58 s, 67 s, 80 s, 43 s, 64 s, 49 s, 46 s, 75 s, 59 s, 63 s, 62 s, 54 s, 50 s, 6
   b) 162 cm, 164 cm, 150 cm, 170 cm, 173 cm, 160 cm, 169 cm, 163 cm,
   c) 36 °C, 40 °C, 45 °C, 37 °C, 29 °C, 34 °C, 41 °C, 32 °C

3. Put the following results in an appropriate table and calculate the me
   Experiment 1: 0 s, 10 °C 5 s, 12 °C 10 s, 20 °C 15 s, 30 °C
   Experiment 2: 0 s, 12 °C 5 s, 15 °C 10 s, 22 °C 15 s, 34 °C

Exam-Style Questions – Tabulated Data and Calculatio

1. Dan has been building various circuits in his Physics lesson. Calculate t using the following equation and copy and complete the table below:

$$Resistance\ \Omega = \frac{Voltage\ (V)}{Current\ (A)}$$

Voltage (V)	Current (A)	Resistance (Ω
1.5	0.5	
1.5	0.25	
3.0	1	
4.5	0.5	

2. Tessa is investigating the amount energy in different fuels. Her results

Fuel	Mass of water (g)	Water tempera	
		Start	**End**
Fuel A	100	291	362
Fuel B	100	293	343
Fuel C	100	292	336

Use these results to calculate the heat energy absorbed by the water b following equation:

$$\text{heat energy absorbed by water(J)} = \text{mc}\Delta\text{T}$$

Where: m = mass of water (g), c = specific heat capacity of water = 4.2
ΔT = temperature change (K)

Recap Questions – Tabulated Data and Calculations

1. Put these data in an appropriate table. Time is measured in seconds a
   0 s, 0 m/s   1 s, 10 m/s   2 s, 20 m/s   3 s, 30 m/s   4 s, 40 m/s   5 s,

2. Calculate the mean of the following sets of data to one decimal place.
   a) 58 s, 67 s, 80 s, 43 s, 64 s, 49 s, 46 s, 75 s, 59 s, 63 s, 62 s, 54 s, 50 s, 6

      ....

   b) 162 cm, 164 cm, 150 cm, 170 cm, 173 cm, 160 cm, 169 cm, 163 cm,

      ....

   c) 36 °C, 40 °C, 45 °C, 37 °C, 29 °C, 34 °C, 41 °C, 32 °C

      ....

3. Put the following results in an appropriate table and calculate the me
   Experiment 1: 0 s, 10 °C   5 s, 12 °C   10 s, 20 °C   15 s, 30 °C
   Experiment 2: 0 s, 12 °C   5 s, 15 °C   10 s, 22 °C   15 s, 34 °C

Exam-Style Questions – Tabulated Data and Calculatio

1. Dan has been building various circuits in his Physics lesson. Calculate t using the following equation and fill in the table below with the resista

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Voltage (V)	Current (A)	Resistance (Ω)
1.5	0.5	
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....

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$$\text{heat energy absorbed by water(J)} = mc\Delta T$$

Where: m = mass of water (g), c = specific heat capacity of water = 4.2 temperature change (K)

Fuel A: ....

....

Fuel B:..

....

Fuel C: ....

....

Lesson Plan 4: Drawing Graph

Learning Aims

Students should understand:
How and when to draw graphs, including:
- bar charts
- line graphs
- pie charts

How to identify anomalous results on graphs

How to draw lines of best fit on graphs:
- appropriate to the data, excluding any anomalies where appropriate
- straight line of best fit
- curve of best fit

Key words: graph drawing, bar charts, pie charts, line graphs, line of best

Starter
Draw a very simple sketch of a bar chart on the board, ask students to ide
Then repeat this for a pie chart and line graph.

Main
1. Introduce graphs as a visual form of representation of data.
2. Teach students how to distinguish between categorical and conti influence choice of graph, i.e. bar chart for categorical variables a variables.
3. Talk through each graph type in turn: bar chart, pie chart, line gra
4. Go around the class asking each person in the room how they travel t board and ask students to draw a pie chart from the information follo information sheet as a guide.
5. Now go around the class asking each person in the room what colour results in the form of a tally and ask students to draw the results in th
6. Explain lines and curves of best fit.
7. Go over graph drawing tips.
8. Ask students to attempt the graph drawing Questions in the pack

Plenary
Quick quiz
- Which graphs should you use to represent categorical variables? *A*
- Which graphs should you use to represent continuous variables? *A*
- How many degrees are there in a circle? Which graph type requires th knowledge? *Answer: there are 360° in a circle. This knowledge is requ*

Graph Drawing

Graphs are visual representations of data. Graph drawing is an essential skill for a
different types of graph for example, bar charts, pie charts and line graphs. When
should choose one that is most appropriate for displaying your results. This will d
are categorical or continuous.

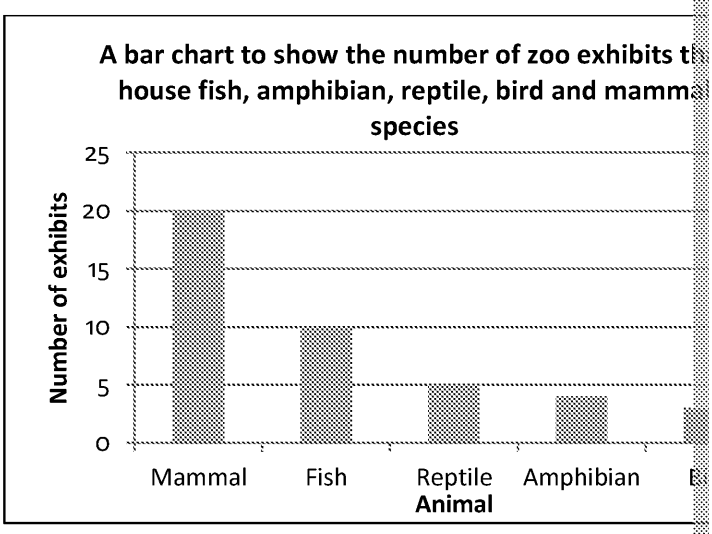
- **Categorical variables** have word labels for example the categories of animals
  examples of categorical variables.

- **Continuous variables** have values that could be any number. They are the va
  temperature.

Graphs also all need titles, labels and units.

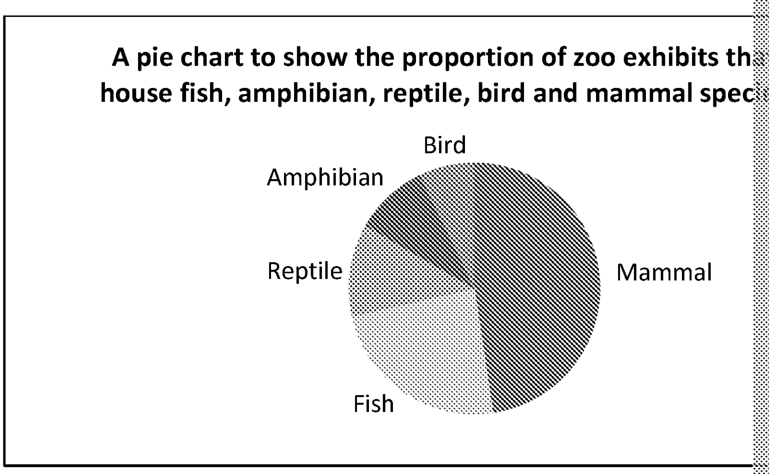
Bar Charts

Bar charts are used to represent categorical variables.



Pie Charts

Pie charts are also used to represent categorical variables, though in this case a p



Drawing Pie Charts

Drawing pie charts requires some calculations. Circles measure 360°, so data in a
as a proportion of 360°.

Example

Melanie counts the number of different birds she sees in her garden over th
are shown in the table below:

Bird species	Number seen
Robin	2
Sparrow	10
Chaffinch	1
Blackbird	7

To turn this data into a pie chart, you can carry out the following calculation
portion of the chart:

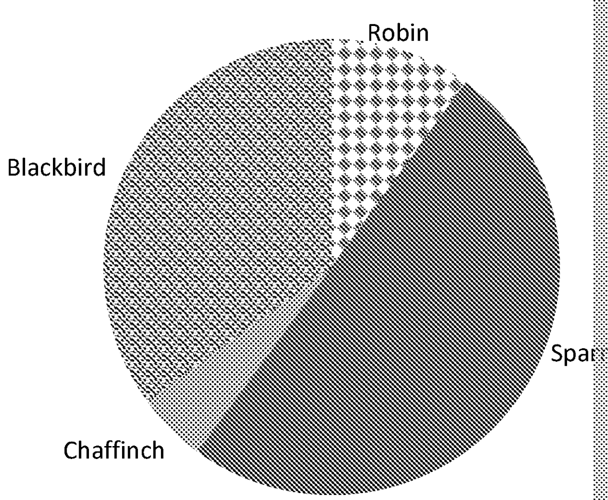
Bird species	No. seen	Calculations	D
Robin	2	2/20 × 360 = 36	
Sparrow	10	10/20 × 360 = 180	
Chaffinch	1	1/20 × 360 =18	
Blackbird	7	7/20 × 360 =126	

To check that you've calculated the values correctly, add them up at the end
total of 360.

36+180+18+126=360

The resulting pie chart is shown below:

A pie chart to represent the number of birds observed
over a two-hour time period

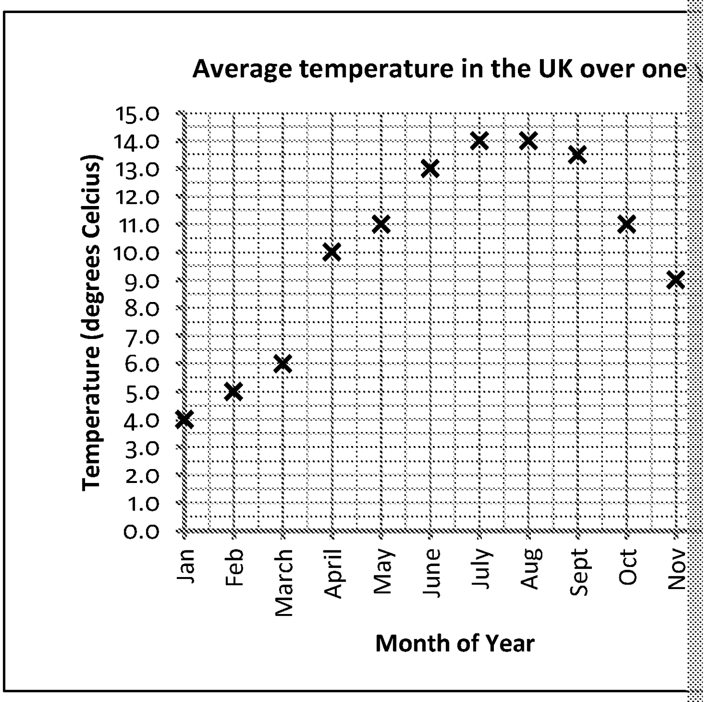


Line Graphs

Line graphs show a connected series of data. Unlike bar charts and pie charts, th
between the points that are plotted.

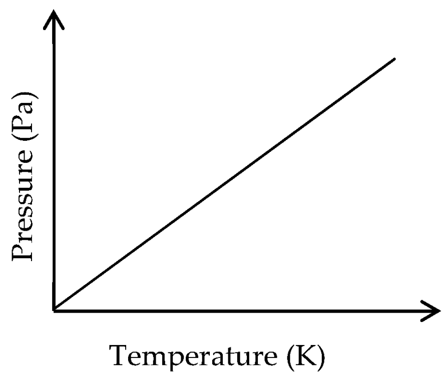
Example

Monthly temperature changes are often plotted as line graphs.



Example

Pressure of a gas in a flask (constant volume) in relation to temperature. For
constant volume, pressure is directly proportional to the absolute temperatu

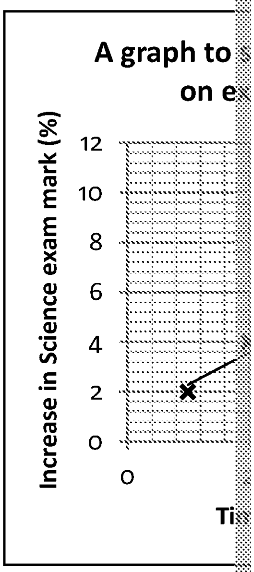


You will notice that in this graph, temperature is measured in Kelvin (K). The
Celsius scale and is a scale commonly used by scientists when measuring tem

Lines of Best Fit

Straight Line of Best Fit

Drawing a line of best fit on your graph can help identify trends such as positive and negative correlation patterns which we will discuss later in this unit.

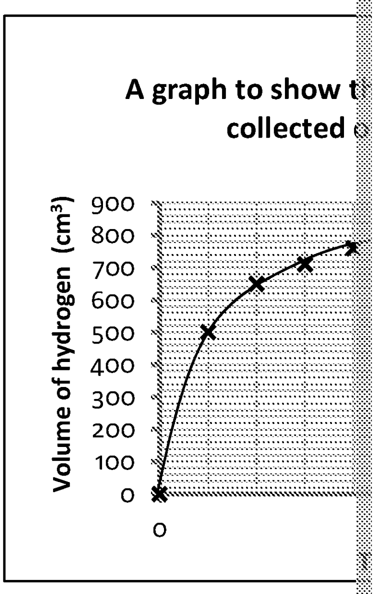


A line of best fit should roughly be drawn through the middle of the points on a scatter graph, it might not go through all the points but the points it doesn't cover should be distributed evenly either side of the line.

When drawing a line of best fit, it should be appropriate for the data, it is acceptable to ignore anomalous results where appropriate.

Curve of Best Fit

Sometimes your data might increase rapidly to begin with and then rise more slowly as the experiment continues, eventually levelling off. In this case a line of best fit would not be appropriate and you should draw a curve of best fit instead.



Where would you draw a curve of best fit on the 'Average temperature in UK over one year' graph on the previous page?

Graph Drawing Tips

- Choose appropriate scales for your axes.
- Label axes correctly and remember to include units of measurement.
- If your graph is in the form of a bar chart, ensure that each of the bars is lab
- Use as much of the graph paper as possible.
- Remember to use a ruler when drawing lines of best fit!

Recap Questions – Drawing Graphs

1. Lucy is investigating ecosystems. She is conducting a small study in h species are preferred by invertebrates. Her results are shown in the tab represent the data and include your calculations.

Plant	No. of invertebrates
Nettle	6
Gorse	10
Heather	3
Fern	1

2. The following table represents the assignment marks for a group of 70 **chart** to represent the data. Remember to label your axes and give an

Grade	No. of students
Level 1	10
Pass	35
Merit	20
Distinction	5

3. The following data represents the average high temperature in Sydney **Draw a line graph** to represent the data.

Month	Temperature (°C)
January	26
February	26
March	25
April	23
May	20
June	18
July	17
August	18
September	20
October	22
November	24
December	26

Recap Questions – Drawing Graphs

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   species are preferred by invertebrates. Her results are shown in the ta
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May	20
June	18
July	17
August	18
September	20
October	22
November	24
December	26

Lesson Plan 5: Obtaining Data from

Learning Aims

Students should understand:
- how to obtain data from a given graph to find a specific value
- how to obtain data from a given graph to carry out calculations

Key words: obtaining data from graphs

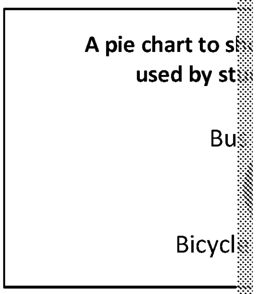
Starter

Revise previous lesson. Copy the following table on the board showing th
that students use to get to school. Ask students to complete the calculation

Transport	No. of students	Calculations	Degrees of circle
Car	11		
Walk	7		
Bicycle	3		
Bus	9		

Answers:

Transport	*No. of students*	*Calculations*	*Degrees of circle*
Car	*11*	*11/30 × 360*	*132*
Walk	*7*	*7/30 × 360*	*84*
Bicycle	*3*	*3/30 × 360*	*36*
Bus	*9*	*9/30 × 360*	*108*



Main

1. Go over the starter exercise.
2. Explain that graphs can be used to obtain specific values. Go over
   to obtain specific data values from a graph.
3. Explain that graphs can be used to obtain data values that can be
   Go over the example illustrating how data values obtained from
   calculations.
4. Ask students to attempt the Questions in the pack.
5. Go over the answers to the Questions.

Plenary

Ask students to practise calculations using the following Questions and th
equation.

1. What is the speed of a car that travels 500 metres in 5 seconds? *Ans*
2. What is the speed of a car that travels 2 metres in 10 seconds? *Ans*

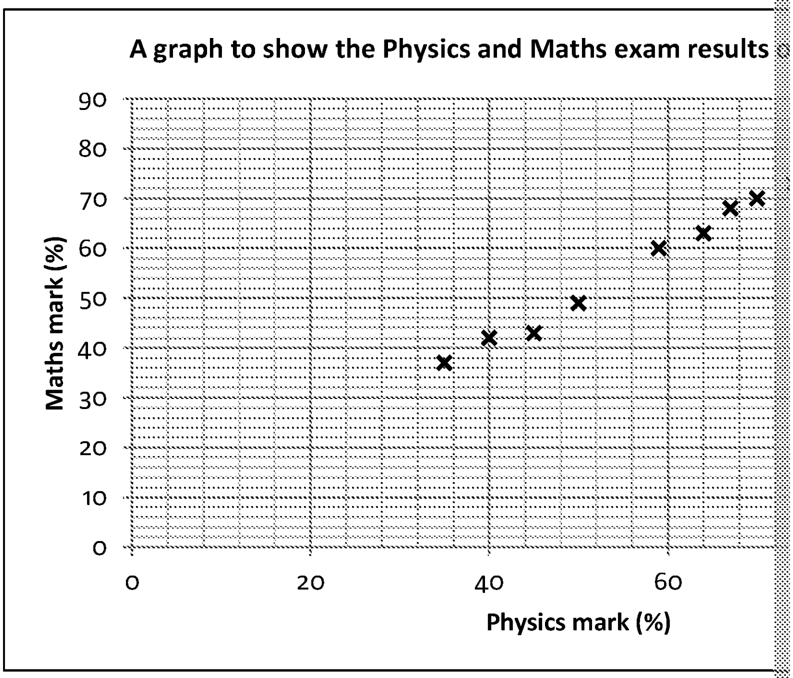
Analysing Graphs

Obtaining Data from Graphs to Find Specific Values

If you have a graph, but no table of results, it is still possible to obtain data value values off the axes of the graph.

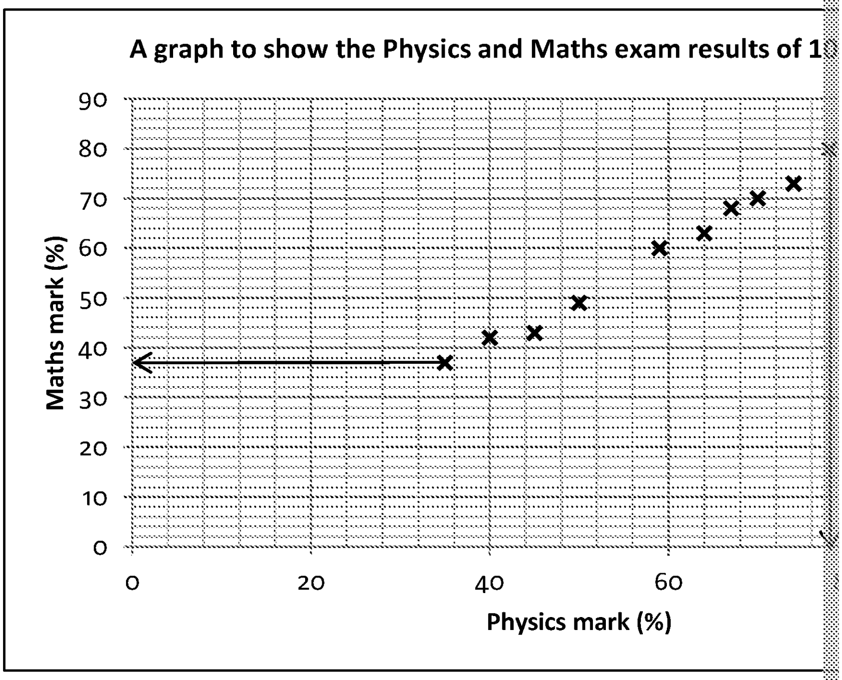
Example

The graph below shows the exam results of 10 students who study Physics a



What was the lowest mark in Maths?
To find the lowest mark in Maths, locate the lowest point on the graph. Draw a line across from the point to the y-axis labelled 'Maths mark'. Read the value on the axis at the end of your line. In this example, the lowest mark in Maths was 37.

What was the highe
To find the highest m point that is furthest t then draw a line dow axis labelled 'Physic on the x-axis at the e example the highest



Obtaining Data from Graphs to Carry Out Calculations

You can use also the data values you obtain from graphs to carry out calculations

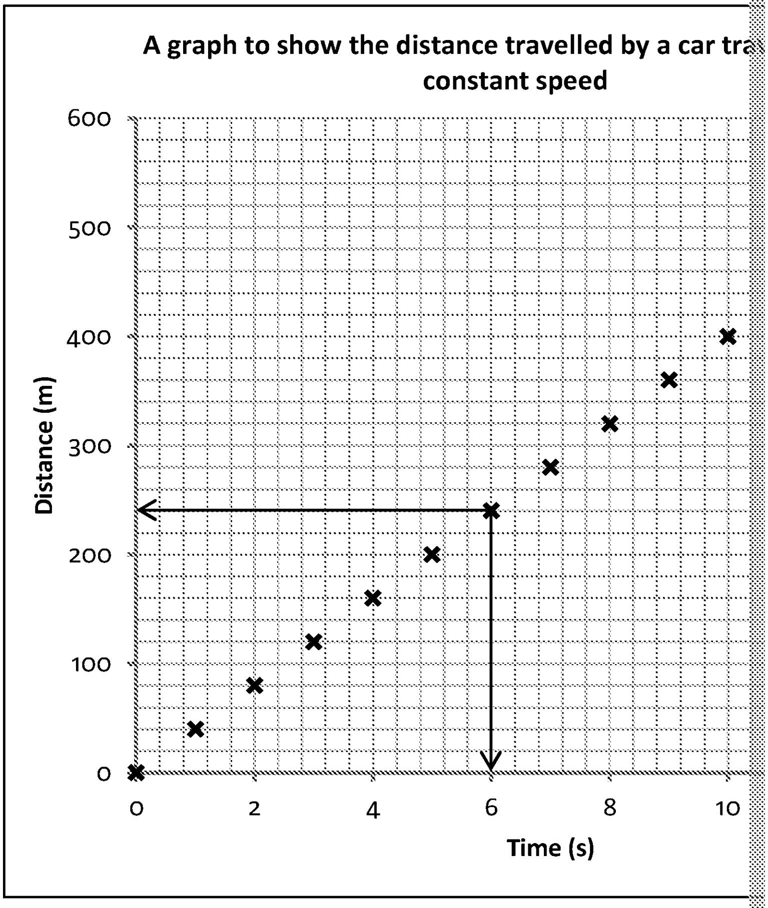
Example

Calculating speed from a distance vs time graph
Speed can be calculated from the gradient of the graph which is obtained axis by the value on the x-axis ($gradient = \frac{y}{x}$).

Task: Calculate the speed of the car

The graph below shows the distance travelled by a car travelling at a **constant speed** over a timescale of 12 seconds.

To calculate the speed of the car, you need to choose a data point. Read the y-axis value. Write it down. Then read the value on the x-axis. Write this down also. Then divide the y value by the x value.



For the point selected, the calculation is as follows:

$$\text{Speed} = \frac{Distance}{Time} = \frac{y}{x} = \frac{240}{6} = 40\ m/s$$

Because the car is travelling at a constant speed, the answer will be the sa choose.

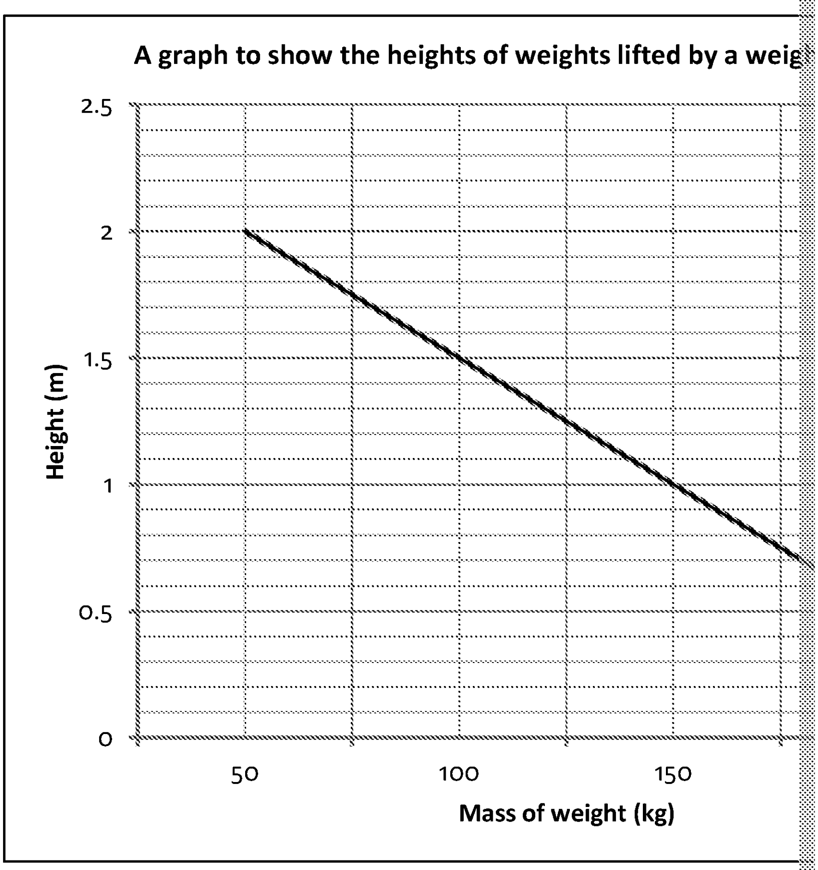
Exam-Style Question – Analysing Graphs

A weight lifter is lifting different sized weights from the ground to differen heights. He records the height he lifts each weight to. A graph of his result shown below.

Using the following equation and the data in the graph, calculate the chan in potential energy (P.E.) of the weight of mass 100 kg.

$$\text{Change in P. E. (J)} = \text{mass (kg)} \times \text{ acceleration due to gravity(N/Kg)}$$

Where acceleration due to gravity = 10



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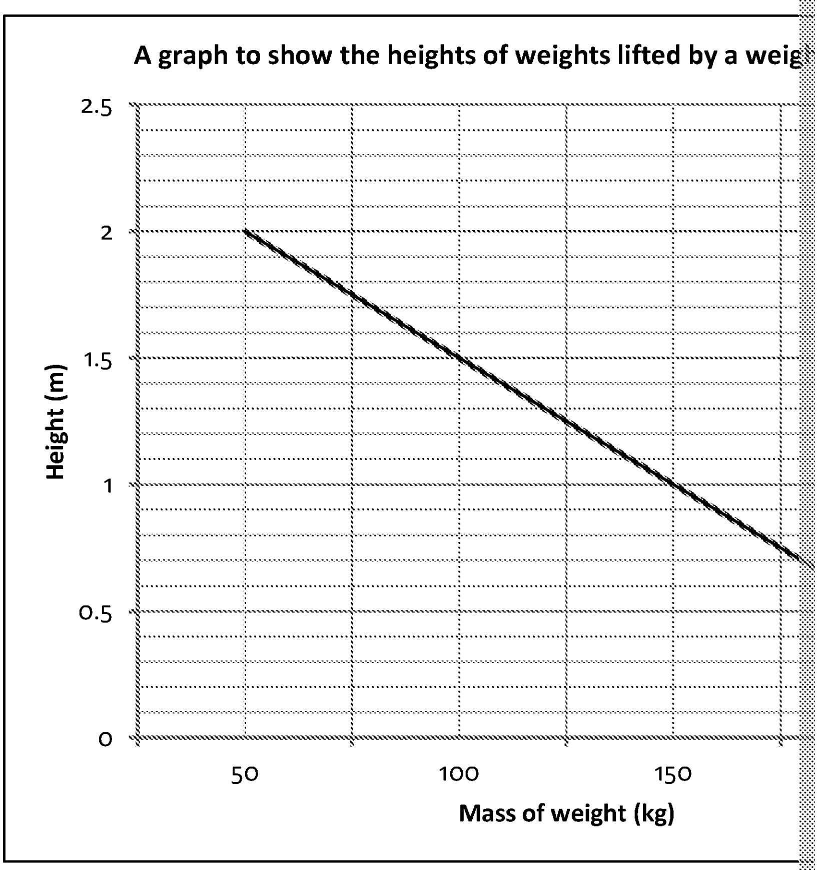
Where acceleration due to gravity = 10



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Lesson Plan 6: Identifying Anomalous Results a They Occur

Learning Aims

Students should understand:

- how to identify anomalous results in tabulated data
- how to identify approaches to deal with anomalous results in tabula
- how to explain why anomalous results occur:
  - when they do not fit the pattern of results
  - due to errors in the experimental process

Key words: Anomalous results

Starter

Copy the following table onto the board and ask students to identify any r pattern of the other results.

1		2	
Time (s)	**Temperature (°C)**	**Time (s)**	**Temperat**
0	0	**0**	0
10	15	**10**	14
20	30	**20**	28
30	44	**30**	40
40	60	**40**	59
50	*50*	**50**	70
60	90	**60**	90

When they have identified the result that doesn't fit the pattern, explain th result.

Main

1. Explain what anomalous results are.
2. Explain how anomalous results are handled.
3. Ask students to attempt the Exam-Style Question.
4. Go over the answer to the Exam-Style Question.

Plenary

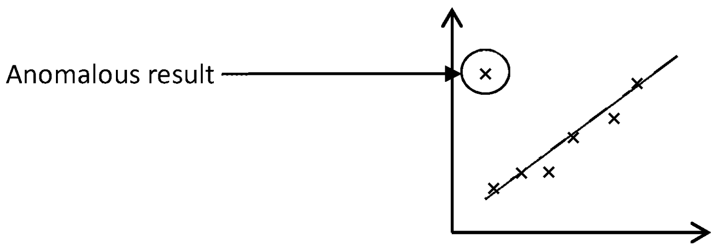
Ask students what they would do if they were to find an anomalous resul collected.

Anomalous Results

An anomalous result (anomaly) is a result that clearly does not fit the pattern of
are usually a consequence of an error in the experimental process. This could be
reading a scale incorrectly, using an inappropriate method or perhaps using fault
could be a perfectly valid scientific reason for an anomalous result. Anomalies ca
research.

Identifying Anomalous Results

Drawing a graph with a line of best fit will often help to identify anomalous resul
best fit has been drawn it is possible to easily identify anomalous results – they a
away from the line (see example below). Anomalous results will also be more ob
repeated a number of times and the results are displayed in the form of a table.
patterns in your results. For example, there may be a decreasing trend as you go
that one value near the bottom of the table increases, this would be an anomalo
apparent anomalous result is not present in the repeated data sets.



Dealing with Anomalous Results

If you find an anomalous result in your data you can re-calculate your averages w
result in your calculation. It is usually best not to include anomalous results whe
data as doing so could lead you to draw incorrect conclusions.

You should however comment on the anomalous result in your evaluation, atten
arisen using your scientific knowledge and suggest how this could be avoided if t
repeated.

Alternatively, you may have enough time to repeat the experiment which had an

Recap Question – Anomalous Results

Find the anomalous result in the following data then recalculate the avera
the anomalous result.

Height ball was dropped from (cm)	Height ball bounced to (cm			
	1	2	3	Av
20	17	18	17	1
25	20	19	7	1
30	23	22	22	2
35	26	25	27	[illegible]
40	30	32	31	[illegible]
45	33	32	33	3

✂---

Recap Question – Anomalous Results

Find the anomalous result in the following data then recalculate the avera
the anomalous result.

Height ball was dropped from (cm)	Height ball bounced to (cm			
	1	2	3	Ave
20	17	18	17	17
25	20	19	7	15
30	23	22	22	22
35	26	25	27	2
40	30	32	31	3
45	33	32	33	32

....

....

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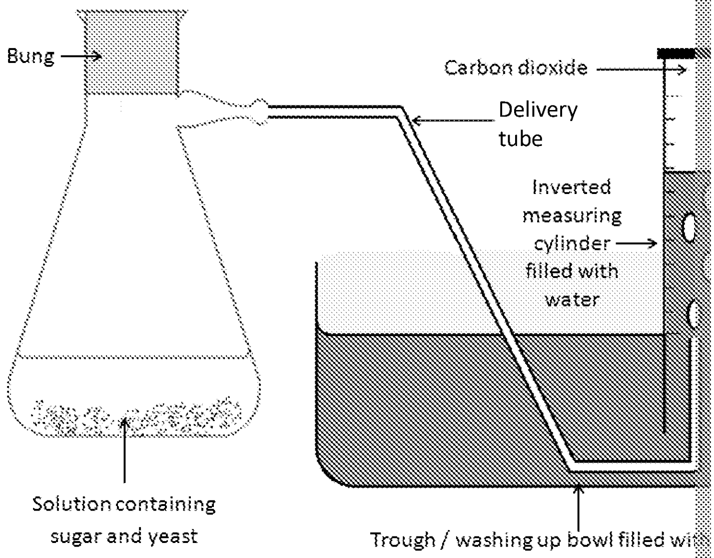
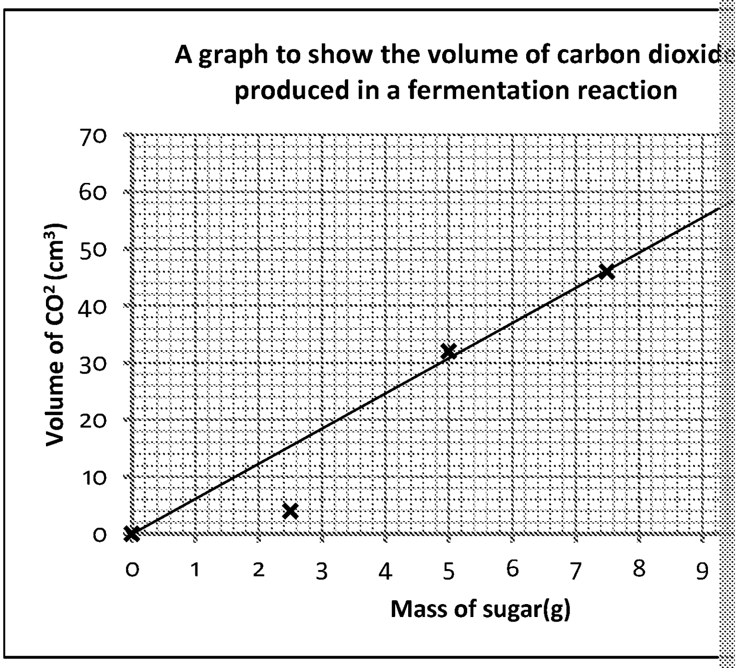
Exam-Style Question – Anomalous Results

Jack is investigating fermentation in yeast. Yeast is an organism that conve
(CO_2) and alcohol in a process called fermentation. The rate of this fermen
investigated by collecting and measuring the amount of carbon dioxide pr

This is done by inverting a measuring cylinder filled with water in trough o
tube from it into a flask containing yeast and sugar. When carbon dioxide
flask through the delivery tube into the inverted measuring cylinder and d
gas bubble at the top of the cylinder which can be measured on the cylind



Jack investigated the effect of different amounts of sugar on the rate of fe
intervals. The diagram above shows his apparatus set up and the graph be



1. Are there any anomalous results?
2. If there are anomalous results, can you suggest reasons why these ma

Exam-Style Question – Anomalous Results

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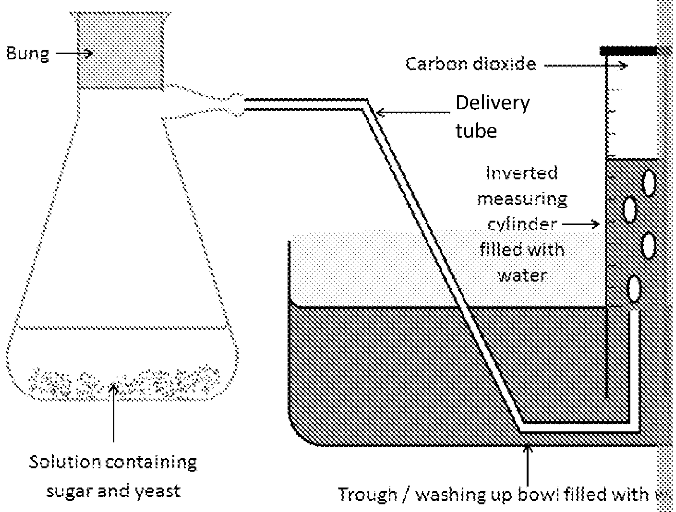

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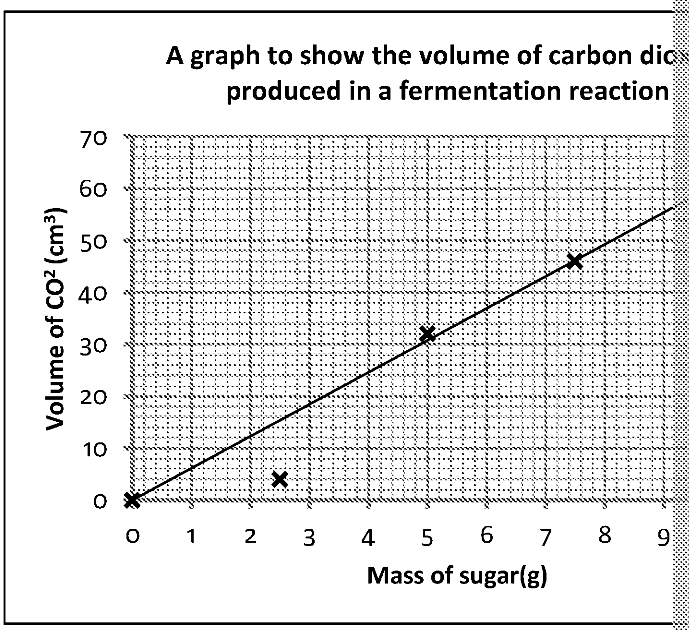


1. Are there any anomalous results?

   ....

2. If there are anomalous results, can you suggest reasons why these ma

   ....

   ....

Lesson Plan 7: Describing Trends and Patter Tabulated Data and Graphs

Learning Aims

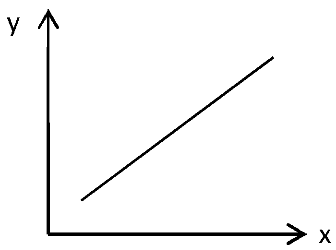
Students should understand:

- how to describe the trends and patterns identified in tabulated data a
- directly and indirectly proportional
- positive and negative correlation
- quantitative relationships

Key words: Trends and patterns in data, directly proportional, indirectly p correlation, negative correlation, quantitative relationships

Starter

Draw the following graph on the board. Ask students to describe what the to x and y values using the words 'increasing' and 'decreasing.'



Main

1. Explain how an explanation of results can be aided by identifying
2. Explain each type of trend in turn – direct proportion, indirect pr and negative correlation.
3. Ask students to attempt the Recap Questions in the pack.
4. Go over answers to the Recap Questions as a class.
5. Ask students to work in pairs to attempt the Exam-Style Questio
6. Go over the answer to the Exam-Style Question as a class.

Plenary

Write down the following definitions on the board, ask students to identif describing:

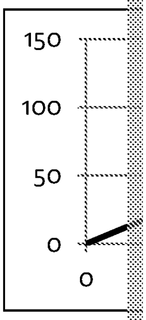
a) two sets of values increasing by the same proportion *Answer*
b) as one set of values increases so does the other *Answer*
c) as one set of values increases, the other decreases *Answer*

Describing Trends and Pattern

Graphs allow you to describe what your results mean; there are a number of diff
you might notice in your data once you've drawn a graph. These are explained b

Directly Proportional

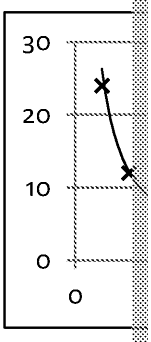
As one quantity increases, a corresponding quantity increases by the same percentage (proportion). So, for example, if you double one quantity, the other one doubles also.



Indirectly Proportional

As one value increases, a corresponding value decreases by the same proportion. For example, as the y value doubles, the x value halves.

For example, if you were climbing a mountain, the higher you go (the higher the altitude) the lower the temperature.



Positive Correlation

As one set of values increases so too does the other set of values. This can be see
in the graph below: as the y value increases, so too does the x value. An example
of positive correlation is seen when investigating the effect of light on the rate o
photosynthesis, as light intensity increases the rate of photosynthesis also increases.

Negative Correlation

As one set of values increases, the other set of values decreases. In this graph th
y value is decreasing as the x value is increasing. An example of negative correlation in Science is, as the concentration of an antibiotic in the body increases, the number of bacteria in the body decreases.

Quantitative Relationships

There are many other types of numerical relationship that can be present in data
relationships. Exponential relationships are those in which values start off very s
increase at a faster and faster rate.

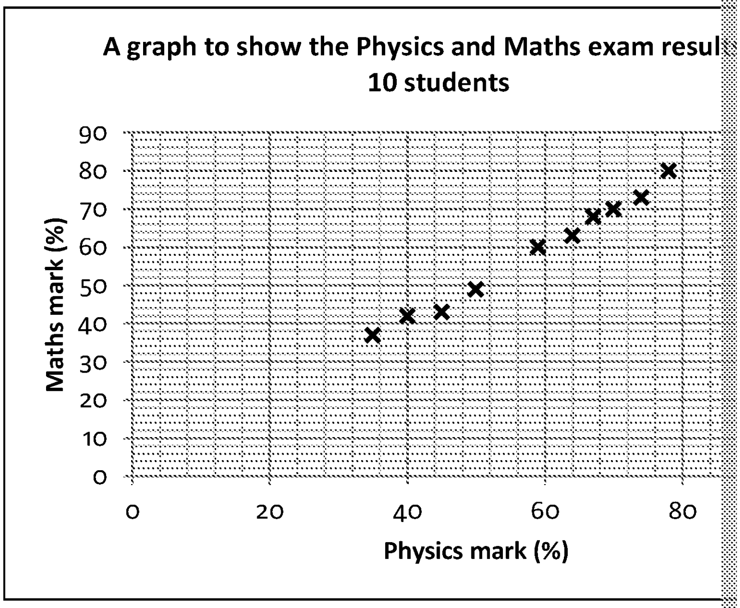
Recap Questions – Trends and Patterns in Graphs

1. Copy and complete the following passage using the words below:

   indirect   negative   patterns   graph

   When you have drawn a ________ you may notice trends or ________ number of possible trends that your data may show including ______ correlation and direct and ___________ proportion.

2. Comment on the relationship shown in the data presented in the grap results of 10 students who study Physics and Maths.



3. The data below represents the weight loss of a person on calorie-restri

Week	Weight (kg)
1	80
2	76
3	74
4	69
5	65
6	61
7	58
8	55

Represent the data in the form of a **scatter plot** and draw a line of bes

Exam-Style Questions – Trends and Patterns in Graphs

Amy has been investigating the effects of different concentrations of alcohol on the heart rate of *Daphnia* (water fleas).

Her results are shown in the table below.

Alcohol (%)	Heart rate (bpm)			
	1	**2**	**3**	**4**
0	126	130	129	127
2	84	86	83	82
4	57	60	57	56
6	42	51	47	49
8	30	40	35	39
10	18	20	19	18

1. Calculate the average (mean) heart rate of the *Daphnia* for each conce

2. Draw a graph to illustrate the results she obtained in experiment one. best fit.

3. Describe the trend you can see in Amy's results.

Recap Questions – Trends and Patterns in Graphs

1. Complete the following passage using the words below:

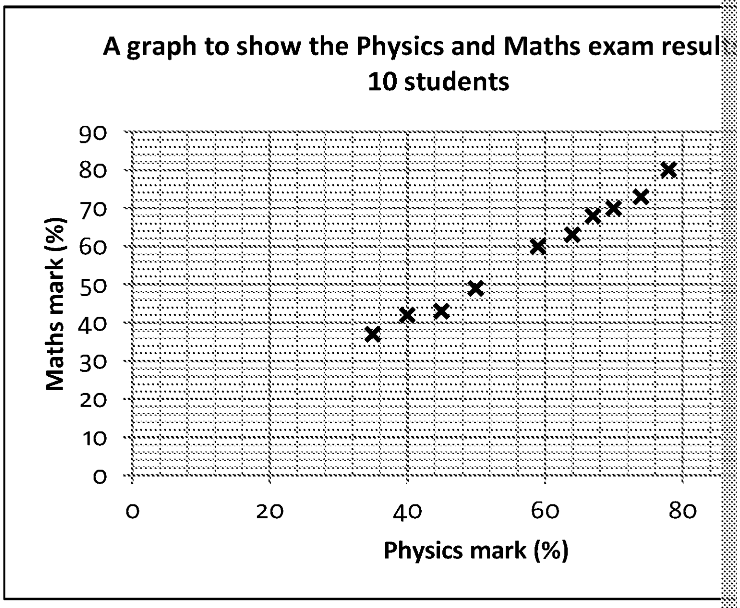
   indirect **negative** **patterns** **graph**

   When you have drawn a _______________ you may notice trends or

   results. There are a number of possible trends that your data may sho

   and _______________ correlation and direct and _______________ p

2. Comment on the relationship shown in the data presented in the grap
   results of 10 students who study Physics and Maths.



....

....

3. The data below represents the weight loss of a person on calorie-restri

Week	Weight (kg)
1	80
2	76
3	74
4	69
5	65
6	61
7	58
8	55

Represent the data in the form of a **scatter plot** and draw a line of best

Exam-Style Questions – Trends and Patterns in Graphs

Amy has been investigating the effects of different concentrations of alcohol on the heart rate of *Daphnia* (water fleas). Her results are shown in table below.

Alcohol (%)	Heart rate (bpm)				
	1	2	3	4	Av
0	126	130	129	127	
2	84	86	83	82	
4	57	60	57	56	
6	42	51	47	49	
8	30	40	35	39	
10	18	20	19	18	

1. Calculate the average (mean) heart rate of the *Daphnia* for each conce the table above with these average (mean) heart rate values.

2. Draw a graph to illustrate the results she obtained in experiment one. best fit.

3. Describe the trend you can see in Amy's results.

....

Lesson Plan 8: Analyse Evidence to Draw

Learning Aims

Students should understand:
- how to analyse evidence to draw a conclusion
- how to comment on the extent to which the evidence supports the co

Key words: Conclusions

Starter
Revise previous lesson. Copy the following passage onto the board and as

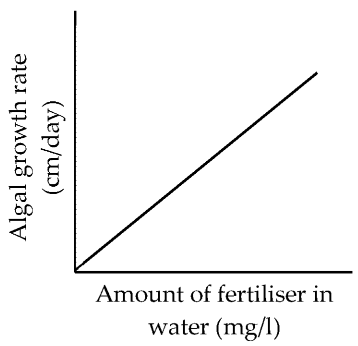
An anomalous result is a result that does not fit the __________ of the rest often the result of an __________ in the experimental process. Drawing a _ ______ ___ can help to identify anomalous results more easily.

Answers: pattern, results, error, graph, line of best fit.

Main
1. Go over the starter exercise.
2. Explain what a conclusion is and give examples.
3. Ask students to attempt the Questions in the pack.
4. Go over the answers to the Questions.
5. Ask students to attempt the Exam-Style Question.
6. Go over the answer to the exam-style question.

Plenary
Draw the following sketch graph on the board. Ask students to write a co evidence in the graph on how the amount of fertiliser in water affects the r

A graph to show the growth rate of algae



Students should conclude that, as the amount of fertiliser in the water incr also increases. This is because fertiliser contains the nutrients that algae re

Conclusions

A conclusion is a summary of what you found out and what your results show, ba
in an experiment.

A conclusion is the point at which you decide whether your results support your h
you to reject your hypothesis or whether they lead to another hypothesis.

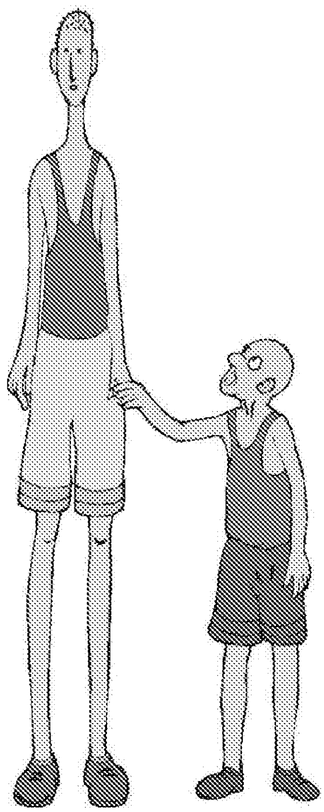
You should comment on the extent to which your data support your conclusion, u
to explain your results.

You might conclude that there is a link between the variables you investigated. R
changed. Consider whether the two are scientifically linked. You might conclude t
variable seems to have brought about a change in the other, the two are not rela
other.

For example

If you carried out an experiment on the effect of temperature on rates of rea
temperature increases, the rate of the reaction increases. These variables are
temperature increase **caused** the increase in the rate of reaction.

If you were studying the relationship between heights and weights of individu
collect data that draws you to conclude that as height increases so does weig
being tall makes you heavier. For example a short overweight person could w
tall underweight person. So in this example although there is correlation, the t
linked.



Recap Question – Conclusions

Copy the following passage into your books and fill in the gaps using the

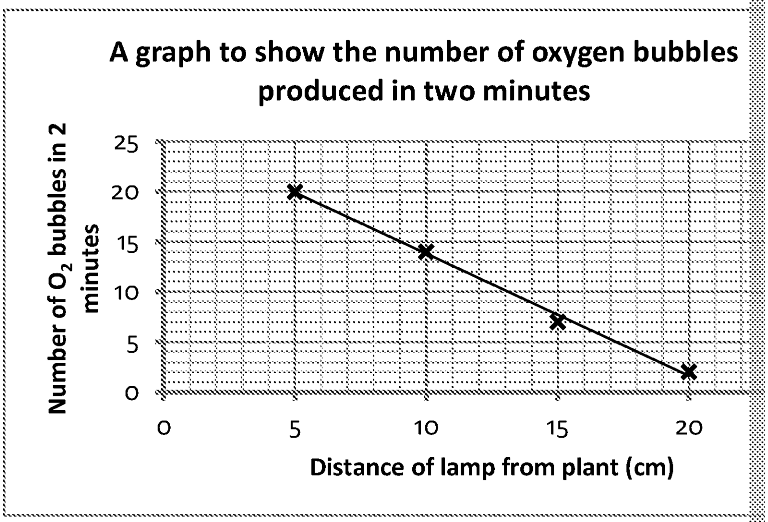
scientific knowledge **support** **summ**

A conclusion is a __________ of what you found out in your experiment. Y
__________ to explain your results and ultimately decide whether your resu
hypothesis or not.

✂ --

Exam-Style Question – Conclusions

Sarah is investigating the effect of light on the rate of photosynthesis in po
photosynthesis is represented by the number of oxygen bubbles given off
photosynthesises the more oxygen it produces. Look at the graph below a
conclusion.



Sarah's conclusion: "*The closer the lamp to the plant the slower t*

Do you agree with Sarah's conclusion based on the evidence presented in
your conclusion be? Can you explain your conclusion using your scientific

Recap Question – Conclusions

Fill in the gaps in the following passage using the words below:

scientific **support** **summary** **knowle**

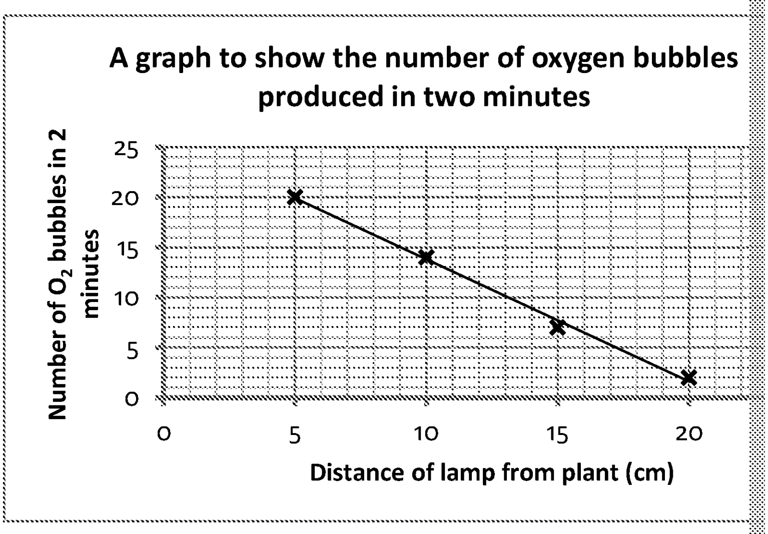
A conclusion is a _______________ of what you found out in your experim

_______________ _______________ to explain your results and ultimately

_______________ your hypothesis or not.

Exam-Style Question – Conclusions

Sarah is investigating the effect of light on the rate of photosynthesis in po photosynthesis is represented by the number of oxygen bubbles given off photosynthesises the more oxygen it produces. Look at the graph below a conclusion.



Sarah's conclusion: "*The closer the lamp to the plant the slower t*

Do you agree with Sarah's conclusion based on the evidence presented in your conclusion be? Can you explain your conclusion using your scientific

....

....

....

....

Lesson Plan 9: Evaluating Evidence and Inves

Learning Aims

Students should understand:
- how to draw inferences from a conclusion
- how to comment on the extent to which the evidence supports the co
- how to comment on the extent to which the hypothesis is supported
- how to evaluate the method, suggesting improvements or ways of e support the hypothesis further

Key words: evaluation, improvements, extending investigations

Starter

Recap the previous lesson on conclusions with the class. Ask students: 'W a conclusion?'
Answers should include:
- *a summary of what you found out in your experiment*
- *an explanation of results based upon scientific knowledge*
- *a decision on whether your results support your conclusion or not*
- *comments on whether the variables investigated were scientifically linked or*

Main

1. Describe the key features of an evaluation:
    - comments on the strengths and weaknesses of the experimen
    - explanation of what the conclusion shows using relevant scie
    - comments on the extent to which the evidence collected supp
    - comments on the extent to which the evidence collected supp
    - includes reference to other evidence that agrees with finding classmate's results, secondary data in books and on the Inter
    - suggests extensions to investigations or further experiments

2. Draw students' attention to the 'Did you know?' box and explain through communication of experimental results. You might like t examples of scientific journals.

3. Ask students to attempt the Questions in the pack.

4. Go over the answers to the Question as a class.

Plenary

Give each student a Post-it note and ask them to write down what they lea evaluations.

Evaluations

An evaluation forms the final part of a scientific investigation. In an evaluation yo
conclusion shows. You should try to explain your conclusion using relevant scien

You should then comment on how well you think your procedure worked. You sh
and weaknesses of your method and suggest ways that you might improve the a
of results.

Accuracy

Accurate measurements are those that are close to the true value. The true valu
would be obtained if a quantity could be measured without any errors.

Precision of measurement

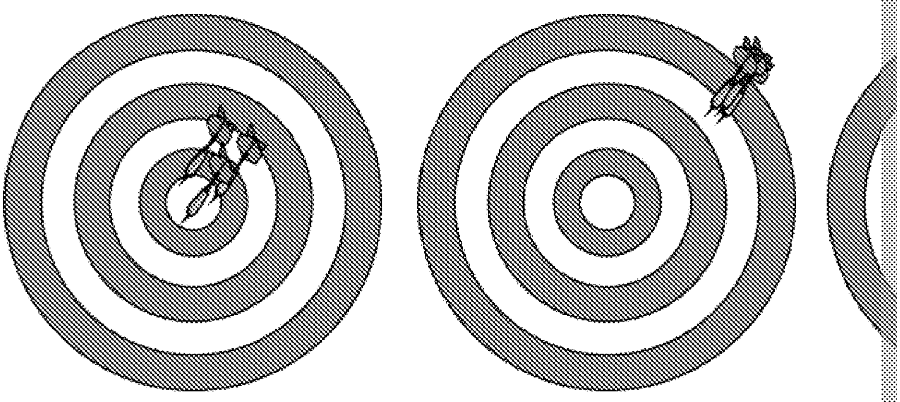
The smallest change that an instrument can measure. It is determined by the lim
being used, e.g. a 3 cm^3 pipette is more precise than a 250 cm^3 beaker.

Precision of results

Small range of values within results, e.g. 2.4, 2.3, 2.1, would be precise as it has a
would not be precise as the range is proportionally much larger.

Reliability

Results are reliable if there is little variation between values obtained upon repe



High accuracy but low precision | **High precision but low accuracy**

Task: Try drawing a similar diagram showing low accuracy and low preci

Comment on what went well and what didn't. Even if you think an experiment w
still be things you can do to make it better and ways of collecting more reliable e
possible improvements to your method. The improvements you make should be
wrong in your experiment or identifying areas where accuracy or precision could

When you've considered the strengths and weaknesses of your experiment, com
evidence you collected supports your conclusion. If you have done many repeats
precise set of readings, then you may have enough evidence to support your con
imprecise, have not been repeated or do not show much of a change then you m
which to draw a reliable conclusion.

Discussing evidence

You should also comment on the **extent to which the hypothesis is supported by the evidence**. Once again, if you have done many repeats and those repeats have shown a precise set of readings and your results seem to match your hypothesis then you may have enough evidence to support your hypothesis. If your results are imprecise, have not been repeated or do not show much of a change then you may not have enough data on which to draw a reliable conclusion to support the hypothesis. Remember, a hypothesis is never proven; it can only be **supported** by the data you collected.

Also **research** whether there is any other evidence that agrees with yours – compare your results with your classmates, also search in books and on the Internet for secondary data that supports your findings. In this part of an evaluation, you could mention research carried out by other scientists.

***Did** **Com** part*

Whe inve the by p publ are jour area

*Jour who the **scie prog know***

Drawing Inferences

You should also try to **draw inferences** from your conclusion, i.e. if one thing is true then another thing may be true, e.g. If red cars are in twice as many accidents as white cars, you could infer that drivers of red cars drive more dangerously than drivers of white cars. You should take care when making inferences that you don't make assumptions that aren't backed up with evidence.

For example

> It was once widely reported that vicars who kept their churches unlocked at
> robbed than those who locked their churches. Many people made the infere
> their churches unlocked to reduce the number of robberies. Whilst this seems
> facts at hand, it does not take into account *why* the vicars had locked their c
> main reason was that they were located in cities with high crime rates, whils
> areas with low crime rates. This is also an example of an associative relatio
> Churches in high crime areas keep their doors locked *and* get robbed more
> robbed more frequently *because* they lock their doors.

Furthermore, try to explain any anomalous results that arose in the data you col problem in the experimental method, was it due to an error in reading, e.g. you Avoid blaming others or making comments that make you or your partner sound take all the results in time as we had to take a recording every minute and we go Next time we will only take recording every two minutes' is fine.

Finally, suggest ways that you could **extend your investigation** to support the hy changing the independent variable or keeping the independent variable the sam measurements. Note: If you have already repeated it three times and got good r five times is not an acceptable answer. Remember you can only draw conclusion found that when you doubled the concentration of hydrochloric acid from 1 mol reaction also doubled, then you could further your investigation to see if this do higher concentrations.

You could also suggest **further experiments** that might provide additional eviden different method. So again, if you found that when you doubled the concentrati dm^3 to 2 mol dm^3 the rate of reaction also doubled, then you could further your effect of doubling the concentrations of other acids such as sulphuric acid or nitr

Recap Questions – Evaluations

1. What three things should be included in an evaluation?

2. An example of an evaluation is given below. What is missing from thi

"Although my experimental method worked well, if I was to investigation again I would use a balance that measures to tw would increase the precision of my results. I would also repea times to increase the reliability of my results."

"My data supported my hypothesis and having researched m other evidence that also supports my findings."

✂ --

Recap Questions – Evaluations

1. What three things should be included in an evaluation?

    1. ....

    2. ....

    3. ....

2. An example of an evaluation is given below. What is missing from thi

"Although my experimental method worked well, if I was to investigation again I would use a balance that measures to tw would increase the precision of my results. I would also repea times to increase the reliability of my results."

"My data supported my hypothesis and having researched m other evidence that also supports my findings."

....

....

Lesson Plans 10–14

Learning Aims

In the context of their investigations, students should:

- Produce a good plan:
  a) identify relevant equipment and give reasons for these choices
  b) identify risks that are relevant to the method and describe how they will be managed (risk assessment)
  c) identify appropriate variables (dependent and independent) and describe how they will be controlled
  d) give a suitable range and number of measurements and explain why these were chosen
  e) outline a logically ordered method appropriate to a given hypothesis
- Provide a hypothesis based on relevant scientific ideas.
- Tabulate data in a clear, logical way.
- Identify anomalous results in tabulated data.
- Identify approaches to deal with anomalous results in tabulated data.
- Carry out appropriate calculations from tabulated data.
- Demonstrate appro and application of which a result can
- Draw appropriate
- Identify anomalou
- Draw appropriate
- Obtain data from a value.
- Obtain data from a calculations.
- Explain why anom
- Describe the appro identified in tabula
- Analyse evidence t
- Draw inferences fr
- Comment on the e supports the conclu
- Comment on the e supported by evid
- Evaluate the metho ways of extending hypothesis further

Starter

Lesson 10: Ask students to list all of the components of a scientific investig

Answer: observation, hypothesis, variables, method, range and number of measur experiment, record results, tabulate data, draw graphs, identify anomalous result conclusion, evaluation

Main

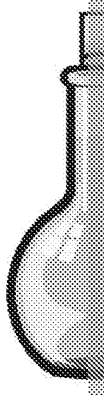
1. Give students a handout of the next page which explains how they sh investigation, talk through this sheet to ensure that all students under to do.
2. **Lesson 10**
   This lesson should be used as a 'planning session'. Students should ch list provided and write plans. These should be approved by you and given to the technician in preparation for next lesson.
3. **Lessons 11 and 12**
   Students should carry out their experiments in these lessons.
4. **Lesson 13**
   In this lesson, students should do calculations, draw tables and graph and comment on any trends or patterns they can see in their data.
5. **Lesson 14**
   Students should use this lesson to write up their conclusions/evaluati

Plenary

At the end of lesson 14, ask students to write down three things they unde their skills through scientific investigation.

How to Write Up a Scientific Invest

On this sheet you will find information on how to write up your scientific investigation. You should use the skills you have learned in this unit to help you.



Firstly choose your scientific investigation from the list provided by your teacher. When you have chosen, write a plan for your experiment, show it to your teacher and make sure it is ok. Over the next two lessons, you will carry out your experiment. Remember to record your results in an appropriate table.

When you've finished carrying out your experiment, you need to do any necessary calculations, draw graphs of your data and write about any anomalous results and trends and patterns that you can see. Then write a conclusion, stating what you found out.

Finally, write an evaluation of your experiment, comment on what went well and if you did the experiment again and how you could further investigate your hypo

Page 1: Cover page with your name and title of your inv

Pages 2–5: Plan
- *hypothesis*
- *variables*
- *method*
- *range and number of measurements*
- *risk assessment*

Pages 6–10: Presentation and analysis of data
- *tables of data*
- *graphs*
- *anomalous results*
- *trends and patterns*
- *conclusion*

Pages 11–12: Evaluation
- *what went well / what didn't*
- *what would you improve if you were to repeat the e*
- *consider whether results support the hypothesis and*
- *suggest further investigations*

Investigation Topics

Below you will find a list of three different experiments, one Biology-related, one Physics-related.

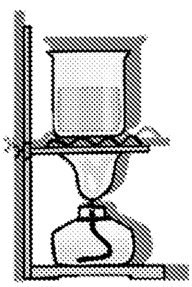
Use the Internet and books to research the science behind the one you are most investigation based upon this experiment.

Biology: Osmosis in Potatoes

Osmosis is the movement of water from an area of high concentration to an area low concentration through a partially permeable membrane.

Osmosis can be investigated by measuring the change in length of raw potato ch submersed in different concentrations of salt solution for a set period of time.

Chemistry: Energy in Alcohols



Different alcohols contain different amounts of energy, whic burned. The energy they release is dependent on their chain

The energy they contain can be calculated by burning the fu and recording the temperature change in the water. The ma be recorded before and after the experiment.

The temperature change can then be used in the following e in the fuel:

Energy J/g = mass of water (g) × 4.2 J K^{-1} g^{-1} *× change in tem*
1 cm^3 *of water is equal to 1 g*

Physics: Cooling of Hot Water

You should know about **energy transfer** between objects from your Physics stud way to investigate this is to investigate the methods that cause a cup of hot wate down.

You could investigate the effect of stirring, blowing on the liquid, leaving a metal the liquid or inserting a spoon into the liquid and removing it again repeatedly.

Record the temperature change that your chosen method induces over a 10-min period.

The Exam

In unit 8 you will be assessed in an externally marked examination.

The exam will be one hour and fifteen minutes long and you will take it under examination conditions.

The exam is worth 50 marks and will include questions on planning, processing, presenting and analysing data, drawing conclusions and evaluating methodology conclusions.

Tips for the Exam

1. Read the question carefully.
2. Make sure that your answer relates to the scenario
3. Double check your calculations.
4. Remember to include units in tables and in any ans even if your calculation is correct, you will lose mar the correct units.
5. Keep an eye on the time, try to have 5 minutes sp exam to check through your answers .
6. Finally, in preparation for your exam, the best thin practise, practise, practise!

Answers to Recap and Exam-Style Qu

Lesson Plan 1 – Producing a Good Plan for Investigation

Recap Questions

1. Correct order is as follows:
   1. question, 2. plan, 3. perform experiment, 4. present data, 5. conclusion, 6. ev
2. A hypothesis is a tentative explanation for an observation that can be tested th
3. 25cm^3
4. A risk assessment is a recognition of elements of an experimental procedure th description of how these will be controlled.
5. Risks can be reduced by wearing protective clothing and paying attention to h harmful, irritant and flammable substances with care.
6. Students should identify hazards and describe what they did to control them.

Lesson Plan 2 – Producing a Good Plan for Investigation (Continu

Exam-Style Questions

1. **Hypothesis** – as the distance of the lamp from the beaker increases, the numbe plant will decrease because as light intensity decreases, the rate of photosynthe
   Variables – the independent variable is the distance of lamp from the beaker c (1 mark), and the dependent variable is the number of oxygen bubbles produc
   Number and range of measurements – change the distance of lamp from beak intervals such as 5 cm, 10 cm, 15 cm, 20 cm (1 mark). Count and record the nu appropriate time scale, e.g. 1 minute (1 mark). Repeat the experiment for each
2. The chemicals being used in this experiment are irritants, so:
   - eye protection should be worn (1 mark)
   - chemicals should be handled with care and spillages should be cleared u
   - if chemicals come into contact with skin they should be washed off imme
   - the experiment should be conducted in a well-ventilated area and ammo breathed in (1 mark)

Lesson Plan 3 – Tabulated Data and Calculations

Recap Questions

1. The table should have appropriate speed values , headings and correct units:

Time (s)	Speed (m/s)
0	0
1	10
2	20
3	30
4	40
5	50

2. a) 60.1 s
   b) 164 cm
   c) 36.8 °C
3. The table should have the correct columns, appropriate headings and correct a

Time (s)	Temperature (°C)		
	Experiment 1	Experiment 2	Average
0	10	12	11
5	12	15	13.5
10	20	22	21
15	30	34	32
20	45	50	47.5

Exam-Style Questions

1. (*Total: 8 marks – 1 mark for each correct answer, and 1 mark for each correct working*

Voltage (V)	Current (A)	Resistance (Ω)
1.5	0.5	3
1.5	0.25	6
3.0	1	3
4.5	0.5	9

$$Resistance(\Omega) = \frac{Voltage\ (V)}{Current\ (A)} = \frac{1.5}{0.5} = 3\Omega$$

$$Resistance(\Omega) = \frac{Voltage\ (V)}{Current(A)} = \frac{1.5}{0.25} = 6\Omega$$

$$Resistance(\Omega) = \frac{Voltage\ (V)}{Current\ (A)} = \frac{3}{1} = 3\Omega$$

$$Resistance(\Omega) = \frac{Voltage\ (V)}{Current\ (A)} = \frac{4.5}{0.5} = 9\Omega$$

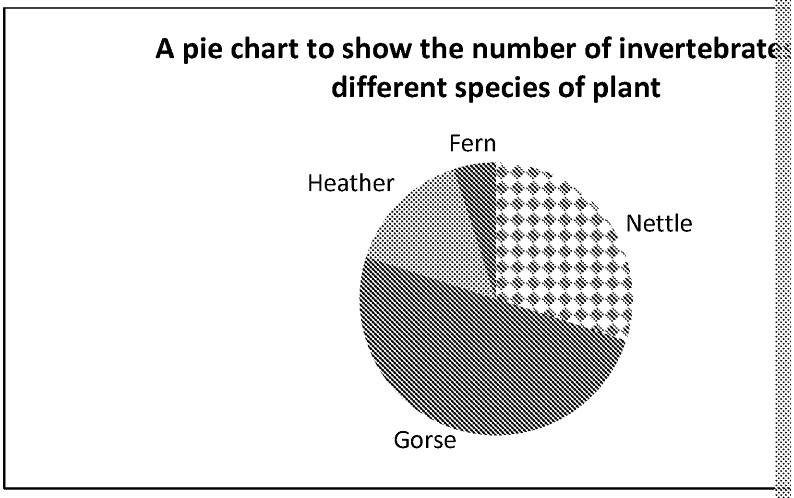
2. Fuel A = 100 × 4.2 × 71 = 29,820 J (2 marks)
   Fuel B = 100 × 4.2 × 50=21,000 J (2 marks)
   Fuel C = 100 × 4.2 × 44= 18,480 J (2 marks)

Lesson Plan 4 – Drawing Graphs

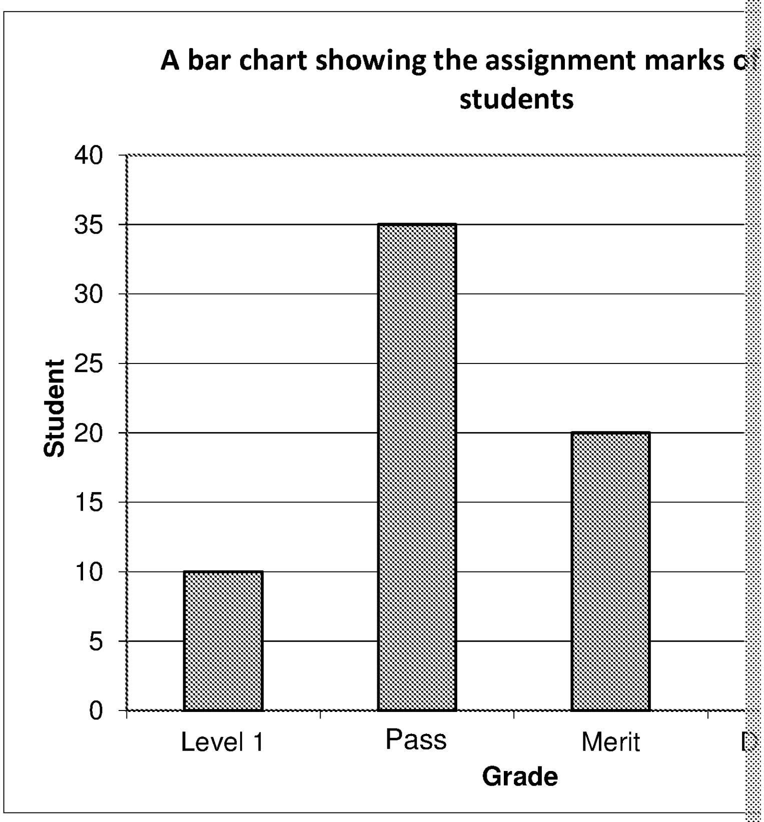
Recap Questions

1. Answer should include the correct calculations and a correctly drawn pie char

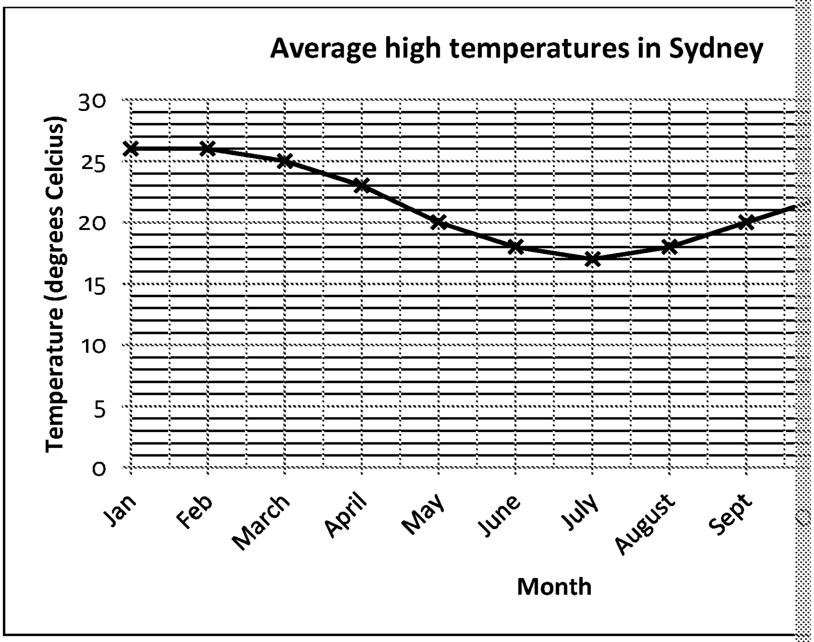
Plant	No. of invertebrates	Calculations	Degree
Nettle	6	6/20 × 360	
Gorse	10	10/20 × 360	
Heather	3	3/20 × 360	
Fern	1	1/20 × 360	



2. Chart should have: labels, an appropriate scale, correctly drawn columns and



3. Graph should have: correctly labelled axes, an appropriate title, correctly plott
   scale.



Lesson Plan 5 – Obtaining Data from Graphs

Exam-Style Question

change in PE (J) = mass (kg) × acceleration due to gravity (N/kg) × change in heig
change in PE (J) = 100 × 10 × 1.5 = 1,500 J

(Total: 3 marks – 1 for extracting the correct data from the graph, 1 for corre

Lesson Plan 6 – Identifying Anomalous Results and Explaining W

Recap Question

Height ball was dropped from (cm)	Height ball bounced to (cm)			
	1	2	3	Average
20	17	18	17	17.3
25	20	19	7	15.3
30	23	22	22	22.3
35	26	25	27	26
40	30	32	31	31
45	33	32	33	32.7

Anomalous result is shaded in grey. Average calculation without anomalous resu

Exam-Style Question

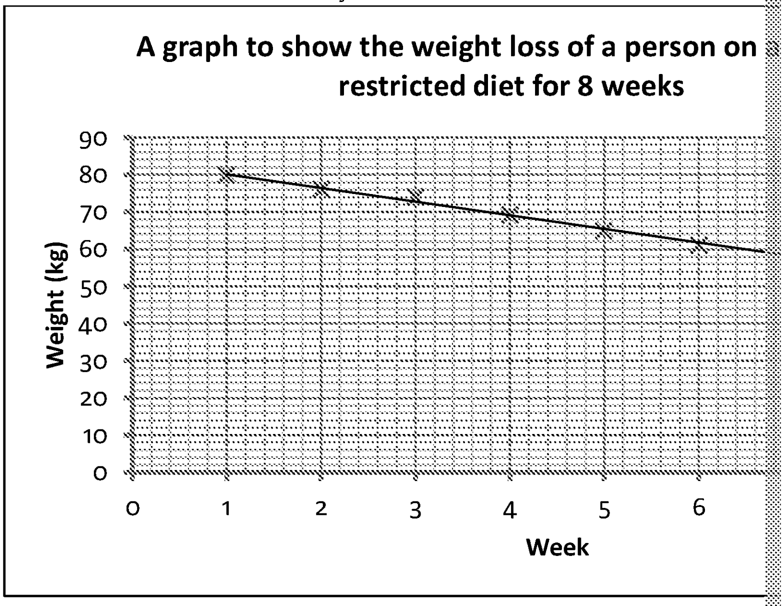
1. Anomalous result at 2.5 g of sugar, 4 cm^3 carbon dioxide (1 mark)
2. May have arisen through:
   - incorrect measurement reading of measuring cylinder
   - incorrect mass of sugar
   - incorrect mass of yeast
   - did not put bung on quickly enough at start of reaction, so some gas escape measured

(1 mark for any of the above

Lesson Plan 7 – Describing Trends and Patterns Identified in Tab

Recap Questions

1. When you have drawn a **graph** you may notice trends or **patterns** in your resu possible trends that your data may show including **positive** and **negative** corr proportion.
2. Graph shows positive correlation between data sets. As the Physics marks inc
3. Graph should include: axes labels with units, appropriate axes scales, an appro points and a line of best fit drawn correctly.

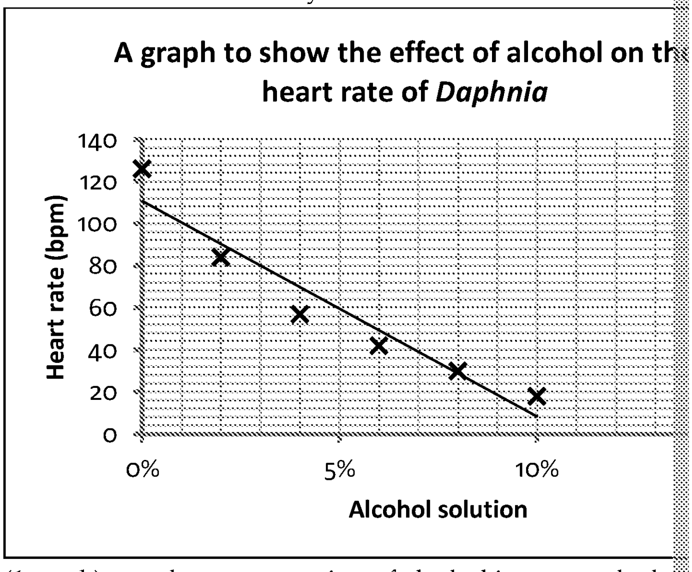


Exam-Style Questions

1. *(Total: 3 marks – 1 mark for each two correct averages calculated)*

Alcohol (%)	Average
0	128
2	83.75
4	57.5
6	47.25
8	36
10	18.75

2. 1 mark for graph title, 1 mark for appropriate axes labels, 1 mark for appropria correctly plotted points and 1 mark for correctly drawn line of best fit.



3. Negative correlation (1 mark) – as the concentration of alcohol increases the he (1 mark).

Lesson Plan 8 – Analyse Evidence to Draw Conclusions

Recap Question

A conclusion is a **summary** of what you found out in your experiment. You shoul
to explain your results and ultimately decide whether your results **support** your h
for each correctly completed sentence).

Exam-Style Question

Disagree with Sarah's conclusion (1 mark). Conclusion from data is that the close
the rate of photosynthesis (1 mark). Scientific explanation: The closer the lamp is t
receives, which increases the rate of photosynthesis (up to a certain point) (1 mark

Lesson Plan 9 –Evaluating Evidence and Investigative Methods

Recap Questions

1. Evaluation of method, suggested improvements and suggested extensions to m
2. There is no mention of extensions to methods or further investigations.