This unit builds on:
unit 3E Magnets and springs in the key stage 2 scheme of work and on unit 7J Electrical circuits.

The concepts in this unit are:
magnets and magnetic materials have important special properties, electromagnets allow magnetism to be switched on and off, and so have many practical applications.

This unit leads onto:
unit 9I Energy and electricity, which includes the generation and uses of electricity.

To make good progress, pupils starting this unit need to know:
• magnets can attract magnetic materials
• magnets attract and repel other magnets
• magnets have a range of uses in everyday life, e.g. fridge door
• how to construct simple circuits.

Magnet and electromagnets

Where this unit fits in
Prior learning
This unit builds on:
unit 3E Magnets and springs in the key stage 2 scheme of work and on unit 7J Electrical circuits.

The concepts in this unit are:
magnets and magnetic materials have important special properties, electromagnets allow magnetism to be switched on and off, and so have many practical applications.

This unit leads onto:
unit 9I Energy and electricity, which includes the generation and uses of electricity.

Framework yearly teaching objectives – Forces
At the end of this unit...
... most pupils will ...
... some pupils will not have made so much progress and will ...
... some pupils will have progressed further and will ...

- make predictions about the behaviour of magnets and magnetic materials and draw conclusions from patterns in evidence
- identify factors affecting the strength of electromagnets
- make sufficient observations in an investigation of electromagnets to draw conclusions.

Expectations from QCA Scheme of Work
At the end of this unit...

In terms of scientific enquiry:
- make predictions about the behaviour of magnets and magnetic materials and draw conclusions from patterns in evidence
- identify factors affecting the strength of electromagnets
- make sufficient observations in an investigation of electromagnets to draw conclusions.

In terms of scientific enquiry:
- make predictions about the behaviour of magnets and magnetic materials and draw conclusions from patterns in evidence
- identify factors affecting the strength of electromagnets
- make sufficient observations in an investigation of electromagnets to draw conclusions.

Suggested lesson allocation (see individual lesson planning guides)

<table>
<thead>
<tr>
<th>Route</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>Magnetic fields</td>
<td>Magnets</td>
<td>Making magnets</td>
<td>Electromagnets</td>
<td>Variables – Think about controlling variables</td>
</tr>
</tbody>
</table>

Extra lessons (not in pupil book)

- Extend time for Activity J2c
- Review and assess progress (distributed appropriately)

Misconceptions
Pupils may believe that all metals are magnetic materials. Many pupils think that the magnetic field of the Earth and gravity are somehow linked.

Health and safety
Iron filings should not be handled by pupils (unless in a sealed container). Coils of electromagnets can get hot when used for some time. The usual precautions taken when using electricity must be observed.

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## J1 Magnetic fields

### Learning objectives

i. The space where a magnet pushes or pulls is called the magnetic field.

ii. The shape and strength of a magnetic field around a bar magnet.

iii. How magnets behave with other magnets and with magnetic materials.

### Scientific enquiry

iv. Describe and explain what their results show. (Framework YTO Sc1 T7)

v. Draw conclusions from their own data. (Framework YTO Sc1 B7)

### Suggested alternative starter activities (5–10 minutes)

- **Introduce the unit**
  - Unit map for Magnets and electromagnets.
  - Introduce the space where a magnet pushes or pulls.
  - Look at the magnetic field around a bar magnet.
  - Find out what happens when you put a magnet near other objects. (Sc1)

### Learning outcomes

- **Share learning objectives**
  - Find out about the space around a magnet.
  - Look at the magnetic field around a bar magnet.
  - Find out what happens when you put a magnet near other objects. (Sc1)

- **Capture interest (1)**
  - Three quick demonstrations using magnets.

- **Capture interest (2)**
  - Show a video clip of everyday uses of permanent magnets.

### Suggested alternative main activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Learning objective see above</th>
<th>Description</th>
<th>Approx. timing</th>
<th>Target group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook J1</td>
<td>i, ii and iii</td>
<td>Teacher-led explanation and questioning OR pupils work individually, in pairs or in small groups through the in-text questions and then onto the end-of-spread questions if time allows.</td>
<td>20 min</td>
<td>C H E S R/G G R S ✔✔ ✔</td>
</tr>
<tr>
<td>Activity J1a Practical</td>
<td>iv and v</td>
<td>What do magnets do? Pupils find out which metals are magnetic and how they behave.</td>
<td>15 min</td>
<td>✔ ✔</td>
</tr>
<tr>
<td>Activity J1b Practical</td>
<td>iv and v</td>
<td>Magnetic forces Pupils investigate the forces between magnets.</td>
<td>20 min</td>
<td>✔ ✔ ✔</td>
</tr>
</tbody>
</table>

### Suggested alternative plenary activities (5–10 minutes)

- **Review learning**
  - Pupils review five things about a magnet.
  - Pupils answer questions about magnets by holding up true/false/unsure cards.

- **Group feedback**
  - Groups of pupils discuss their responses to question 5 in Activity J1a (Core).

- **Word game**
  - Pupils answer clues to fill in a grid and find a mystery word.

- **Looking ahead**
  - Pupils predict the magnetic field pattern in the space between the poles of two bar magnets.

### Learning outcomes

- **Most pupils will ...**
  - Describe the shape and direction of the magnetic field around a bar magnet.
  - Distinguish between magnetic and non-magnetic materials.
  - Make predictions about how magnetic materials will behave in a magnetic field.

- **Some pupils, making less progress will ...**
  - Realise that magnets can push and pull without touching.
  - Identify steel, iron and iron oxide as magnetic materials.

- **Some pupils, making more progress will ...**
  - Also make predictions about the effects of the magnetic field based on the pattern of magnetic field lines.

### Key words

- attract, bar magnet, magnetic field, magnetic materials, north pole, south pole, repel, poles, iron filings, magnetic field lines

### Out-of-lesson learning

- **Homework J1**
  - Textbook J1 end-of-spread questions
  - Make a list of examples of magnets being used around the home.
**Lesson planning guide**

### Learning objectives

i. The Earth's magnetic field

ii. The direction and shape of the magnetic field around a bar magnet and the Earth

iii. How magnets are used in navigation.

iv. Magnetic shielding (red only)

### Suggested alternative starter activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Recap last lesson</th>
<th>Share learning objectives</th>
<th>Problem solving</th>
<th>Capture interest (1)</th>
<th>Capture interest (2)</th>
</tr>
</thead>
</table>
| Whole class discussion of the answers to questions on an OHT. | • Find out about the Earth's magnetic field.  
• Be able to plot magnetic fields.  
• Be able to use the Earth's magnetic field to navigate. | Pupils discuss how they would find their way out of a forest/jungle if they were lost. | Show video clip of ship's navigation system or orienteering.  
Catalyst Interactive Presentations 2 | Demonstration of magnetic shielding |

### Activity

<table>
<thead>
<tr>
<th>Description</th>
<th>Approx. timing</th>
<th>Target group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-led explanation and questioning OR pupils work individually in pairs or in small groups through the in-text questions and then onto the end-of-spread questions if time allows.</td>
<td>20 min</td>
<td>N/G G R S</td>
</tr>
<tr>
<td>Plotting magnetic fields Pupils use a small plotting compass to show the pattern of the magnetic field of a bar magnet.</td>
<td>20 min</td>
<td>✔ ✔</td>
</tr>
<tr>
<td>Using a compass to navigate. Working in groups pupils use a compass to navigate a route to find some hidden treasure.</td>
<td>30 min</td>
<td>✔ ✔</td>
</tr>
<tr>
<td>William Gilbert. Pupils use books and the Internet to find out about William Gilbert, who discovered that the Earth is magnetic.</td>
<td>30 min</td>
<td>✔</td>
</tr>
<tr>
<td>Support animation activity for pupils who need help investigating the Earth's magnetic field.</td>
<td>10 min</td>
<td>✔</td>
</tr>
</tbody>
</table>

### Suggested alternative plenary activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Sharing responses</th>
<th>Group feedback</th>
<th>Word game</th>
<th>Looking ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils answer multiple-choice questions.</td>
<td>Pupils recap magnetic field patterns found in Activity J2a.</td>
<td>Pupils find out what is in a mystery box and each group reports back on its findings.</td>
<td>Pupils play bingo.</td>
<td>Demonstration of picking up a line of steel paper clips/pins and iron nails with a bar magnet.</td>
</tr>
</tbody>
</table>

### Learning outcomes

**Most pupils will ...**

- describe how the Earth's magnetic field can be used for navigation
- describe how a magnet can be used as a compass
- describe how a compass can be used to show the direction of a magnetic field.

**Some pupils, making less progress will ...**

- realise that a magnet can be used to point north
- know that a magnetic field has direction.

**Some pupils, making more progress will ...**

- also identify similarities in the magnetic field around the Earth and around a bar magnet
- also describe magnetic shielding.

### Key words

- compass, navigate, red only: magnetic shielding

### Out-of-lesson learning

- Homework J2
- Textbook J2 end-of-spread questions
- Find out about historic methods of navigation. Visit the National Maritime museum at Greenwich. Read Longitude by Sobel.
Lesson planning guide

Making magnets

Learning objectives

i Describe how to make a magnet.

Scientific enquiry

ii Use a model of groups of magnetic particles to explain the behaviour of magnets and magnetic materials. (red only)

iii Use a simple test to distinguish between a magnet and some magnetic material. (green only)

iv Use a range of first hand experience and secondary sources of information to present information and draw conclusions from their own data.

v Identify more than one strategy for investigating questions. (Framework YTO Sc1 8b)

Suggested alternative starter activities (5–10 minutes)

Recap last lesson

Pupils talk for one minute about the Earth’s magnetic field.

Share learning objectives

• Find out what happens when something is magnetised.
• Find out about a theory of magnetism. (red only)
• Be able to make a magnet by the stroking method. (Sc1)

Problem solving

Pupils discuss how cans made from different materials could be separated.

Capture interest (1)

Demonstration of stroking a tube of iron filings with a magnet.

Capture interest (2)

Animation showing particles in a piece of iron or steel gradually lining up as the sample is stroked with a bar magnet.

Catalyst Interactive Presentations 2

Suggested alternative main activities

Activity Textbook J3 Activity J3a Practical Activity J3b Practical Activity J3c Catalyst Interactive Presentations 2

Learning objective see above i and ii i, iii and iv i, iv and v i

Description Teacher-led explanation and questioning OR pupils work individually, in pairs or in small groups through the in-text questions and then onto the end-of-spread questions if time allows. Making magnets. Pupils make a magnet from a steel strip (or a test tube of iron filings) by stroking it with a bar magnet and test its strength. Making a compass. Pupils try two ways of making a compass. Extension activity to show the domain theory of magnetism.

Approx. timing 20 min 25 min 20 min 10 min

Target group C H E S R G G R S ✔ ✔ ✔ ✔

Suggested alternative plenary activities (5–10 minutes)

Review learning

Working in pairs, pupils prepare four questions for their partner to answer.

Sharing responses

Pupils all stand up and sit down when they have defined a word correctly.

Group feedback

Group discussion of results of activity J3a or J3b.

Word game

Check progress - Pupils fill in the gaps in a passage summarising the unit so far.

Looking ahead

Demonstration of the electrical method of making a magnet.

Learning outcomes

Most pupils will ...

• make a magnet
• describe a test to tell the difference between a magnet and magnetic material.

Some pupils, making less progress will ...

• make a magnet
• carry out a test to tell the difference between a magnet and magnetic material.

Some pupils, making more progress will ...

• also explain how magnetic materials can be magnetised using a simple particle model.

Key words

lodestone, permanent magnet, temporary magnet

Out-of-lesson learning

Homework J3

Textbook J3 end-of-spread questions

Extension pupils could find out more about the domain theory of magnetism

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Electromagnets

Learning objectives

i) Know that a current flowing in a wire makes a magnetic field.

ii) Describe the shape of the magnetic field around a coil of wire.

iii) Describe some uses of electromagnets.

Scientific enquiry

iv) Identify more than one way to make an electromagnet stronger. (Framework YTO Sc1 8b)

v) Use first-hand experience to collect and present information, using appropriate range and precision. (Framework YTO Sc1 8d, e)

vi) Draw conclusions from their own data. (Framework YTO Sc1 8f)

Suggested alternative starter activities (5-10 minutes)

Recap last lesson

Pupils think of five important things to remember when making magnets.

Share learning objectives

- Find out about the magnetic field due to a solenoid.
- Find out the effect of adding a metal core.
- Be able to make an electromagnet. (Sc1)

Suggested alternative main activities

Activity Textbook J4

Learning objective see above

Description Teacher-led explanation and questioning OR pupils work individually, in pairs or in small groups through the in-text questions and then onto the end-of-spread questions if time allows.

Activity J4a Practical

Learning objective i, ii, iv, v and vi

Description Making an electromagnet. Pupils look at the magnetic field due to a current in a solenoid (coil of wire) or a long straight wire.

Activity J4b Practical

Learning objective i, iv, v and vi

Description Adding a core to an electromagnet. Pupils see the effect of using rods made from various materials.

Activity J4c Paper

Learning objective iii

Description Designing a burglar alarm. Pupils design a circuit using a relay to act as a burglar alarm that is activated by opening a window or door.

Approx. timing

20 min 15 min 20 min 15 min

Target group

C H E S

R/G G R S

✔✔ ✔ ✔

Suggested alternative plenary activities (5-10 minutes)

Review learning

Loop game revising the work done so far in this lesson.

Sharing responses

Whole class discussion of the results of Activity J4a or J4b.

Word game (1)

Demonstration of a relay. Pupils write a series of statements in the correct order to explain how a relay works.

Word game (2)

Word search to familiarise pupils with the terminology used in this unit.

Looking back

Pupils revise and consolidate knowledge from the unit.

Learning outcomes

Most pupils will ...

- describe the shape of the magnetic field around a current-carrying straight coil solenoid
- be able to make an electromagnet
- give examples of the use of electromagnets to include sorting scrap, trains, electric locks, etc.
- identify factors affecting the strength of electromagnets.

Some pupils, making less progress will ...

- describe the shape of the magnetic field around a straight (not coiled) conductor
- identify similarities between the shapes of the magnetic fields around a bar magnet, the Earth and a straight coil solenoid
- use the model of groups of magnetic particles to explain why adding an iron core increases the strength of an electromagnet.

Some pupils, making more progress will ...

- describe the shape of the magnetic field around a current-carrying straight coil solenoid
- make an electromagnet
- make changes to vary the strength of an electromagnet.

Key words

electromagnet, core, red only: solenoid

Out-of-lesson learning

Homework J4

Textbook J4 end-of-spread questions

Research other uses of electromagnets or relays. Find out about Faraday's work/other scientists work on electromagnetism. Visit the electromagnetism section of the Science Museum in London.
**Variables - Think about controlling variables**

**Learning objectives**
- Investigate key variables that alter the strength of electromagnets.
- The structure of this lesson is based around the CASE approach. The starter activities give concrete preparation. The main activities move away from the concrete towards a challenging situation, where pupils need to think. The extended plenary gives pupils time to discuss what they have learnt, to negotiate a method to commit to paper and express their ideas verbally to the rest of the class.

**Scientific enquiry**
- Evaluating different methods of doing the same investigation. (Framework YTO Sc1 8b)
- Using the correct chart or graph to analyse results. (Framework YTO Sc1 8d)
- Draw conclusions and use scientific knowledge to explain them, consider whether the investigation could have been improved. (Framework YTO Sc1 8f, g)

**Suggested alternative starter activities (5-10 minutes)**

**Bridging to the unit**
- Demonstrate weak and strong electromagnets and/or show video clips of weak and strong electromagnets being used. 
  Catalyst Interactive Presentations 2

**Concrete preparation**
- Teacher-led discussion on the meaning of input and outcome variables and the need to control variables to ensure a fair test.
- Teacher-led discussion on how to make an electromagnet in a logical sequence.

**Concrete preparation (2)**
- Teacher-led discussion on how to analyse results.

**Suggested alternative main activities**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Learning objective see above</th>
<th>Description</th>
<th>Approx. timing</th>
<th>Target group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook J5</td>
<td>i, ii, iii, and iv</td>
<td>Teacher-led explanation and questioning OR pupils work individually, in pairs or in small groups through the in-text questions and then onto the end-of-spread questions if time allows.</td>
<td>30 min</td>
<td>R/G G K S</td>
</tr>
</tbody>
</table>

**Suggested alternative plenary activities (5-10 minutes)**

**Group feedback**
- Pupils discuss what is meant by a key variable and the different methods of measuring dependent/outcome variables.

**Bridging to other topics**
- The importance of controlling variables in an investigation.

**Learning outcomes**

<table>
<thead>
<tr>
<th>Most pupils will ...</th>
<th>Some pupils, making less progress will ...</th>
<th>Some pupils, making more progress will ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>• realise that it is important to make sufficient observations during an investigation to be sure of their conclusion</td>
<td>• realise that changing the core, the number of turns in the coil and the current changes the strength of an electromagnet</td>
<td>• evaluate alternative methods of carrying out the same investigation</td>
</tr>
<tr>
<td>• use the correct chart/graph to analyse results.</td>
<td>• use charts or graphs to analyse results.</td>
<td>• explain why they selected a bar chart or a line graph to analyse results.</td>
</tr>
</tbody>
</table>

**Key words**
- key variables

**Out-of-lesson learning**
- Textbook J5 end-of-spread questions

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Investigate: How to make an electromagnet stronger

Learning objectives

i. Use ideas about magnetic forces in an investigation into the effect of distance on the size of the attractive force between a magnet and a steel sheet.

Scientific enquiry

ii. Make predictions of possible outcomes. (Framework YTO Sc1 7b)

iii. Identify and control the key factors that are relevant to the investigation. (Framework YTO 7c)

iv. Collect, store and present information. (Framework YTO Sc1 8a)

v. Use appropriate range, precision and sampling when collecting data. (Framework YTO Sc1 8d)

vi. Draw conclusions from data and describe how their conclusions are consistent with the evidence obtained. (Framework YTO Sc1 8f)

Learning outcomes

Most pupils will ...

• carry out steps in an investigation, using their ideas about burning in their explanation.

Some pupils, making less progress will ...

• with help, carry out all steps in an investigation and relate their ideas about burning to their results.

Some pupils, making more progress will ...

• also use their ideas about burning to explain their prediction and explain any anomalous results.

Suggested alternative starter activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Setting the context</th>
<th>Introduce the apparatus</th>
<th>Safety</th>
<th>Brainstorming (1)</th>
<th>Brainstorming (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss the uses of an electromagnet and the need to be able to vary its strength.</td>
<td>Pupils discuss the basic apparatus that could be used to make an electromagnet and vary its strength.</td>
<td>Pupils discuss the hazards of the investigation and the steps they must take to ensure their safety.</td>
<td>Pupils discuss the variables in the investigation and how to control the other variables to ensure a fair test.</td>
<td>Pupils brainstorm ways of measuring the strength of the electromagnet.</td>
</tr>
</tbody>
</table>

Investigation

Activity | Learning objective | Description | Approx. timing | Target group |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity J5 Practical</td>
<td>see above</td>
<td>Pupils plan and carry out an investigation to find out what makes an electromagnet stronger. They collect some evidence and draw a graph to help them analyse the data and to evaluate your results.</td>
<td>50 min</td>
<td>C H E S</td>
</tr>
</tbody>
</table>

Suggested alternative plenary activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Group feedback</th>
<th>Analysing</th>
<th>Evaluating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-led review of the planning procedure.</td>
<td>Groups discuss their results and report to the class.</td>
<td>Teacher-led analysis of the investigation.</td>
<td>Teacher-led evaluation of the investigation.</td>
</tr>
</tbody>
</table>

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Magnets and electromagnets

Copy the unit map and use these words to help you complete it.
You may add words of your own too.

attract  magnetic shielding
compass  navigation
current  north-seeking
Earth's magnetic field  poles
emagnet  repel
force  solenoid
iron  south-seeking
magnet  space
magnetic field  steel
magnetic materials
Magnetic fields

Suggested alternative starter activities (3–10 minutes)

<table>
<thead>
<tr>
<th>Introduce the unit</th>
<th>Share learning objectives</th>
<th>Capture interest (1)</th>
<th>Problem solving</th>
<th>Capture interest (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit map for magnets and electromagnets.</td>
<td>Find out about the space around a magnet.</td>
<td>Three quick demonstrations using magnets.</td>
<td>Pupils look at a travel version of a board game and decide how it works and what materials could be used to make it.</td>
<td>Show a video clip of everyday uses of magnets. [Catalyst Interactive Presentations 2]</td>
</tr>
</tbody>
</table>

Introduce the unit

- Either draw the outline of the unit map on the board then ask pupils to give you words to add, saying where to add them. Suggest some words yourself when necessary to keep pupils on the right track.
- Or give out the unit map and ask pupils to work in groups deciding how to add the listed words to the diagram. Then go through it on the board as each group gives suggestions.

Share learning objectives

- Ask pupils to write a list of FAQs they would put on a website telling people about magnets. Collect suggestions as a whole class activity, steering pupils towards those related to the objectives. Conclude by highlighting the questions you want them to be able to answer at the end of the lesson.

Capture interest (1)

- Ask the whole class, "What is meant by a magnetic field?" Hold a bar magnet above some steel pins/iron nails/paper clips so that pupils can see them jump up to the magnet. This should lead to the idea that a magnetic field is the space around a magnet where its effect is felt.
- Show the magnetic field pattern for a bar magnet on an OHP using iron filings or iron needles in bubbles.
- Try to pick up a selection of different materials using a bar magnet. Start to compile a list of magnetic and non-magnetic materials. Add to it at the end of the lesson.

Problem solving

- Show pupils a travel version of a board game (e.g. Scrabble, solitaire, backgammon). Pupils are asked questions about how it works and what materials could be used to make it.

Questions

- Why couldn’t you play Scrabble (say) on a train or on a car journey using an ordinary version of the game?
- What is special about the travel version?
- Why don’t the pieces move around?
- What do you think they are made from?
- What do you think the board is made from?

Capture interest (2)

- Show pupils a video clip of everyday uses of magnets.
- Discuss how the monorail might work.

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Magnetic fields

Capture interest (1)

Technician sheet
Supply the following for three short demonstrations:

Demonstration 1
- bar magnet
- paper clips or steel pins or iron nails (check the steel pins are magnetic)

Demonstration 2
- OHP
- bar magnet placed on OHP under acetate sheet (to stop iron filings clinging to magnet)
- iron filings in sprinkler
  or
- OHP
- iron needles in bubbles

Demonstration 3
- bar magnet
- selection of items made from different materials, some magnetic, some non-magnetic e.g.
  - paper
  - iron
  - steel
  - aluminium
  - brass
  - copper
  - polystyrene
  - glass
  - wood
  - plastic
Magnets

Suggested alternative starter activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Recap last lesson</th>
<th>Share learning objectives</th>
<th>Problem solving</th>
<th>Capture interest (1)</th>
<th>Capture interest (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole class discussion of the answers to questions on an OHT.</td>
<td>Find out about the Earth's magnetic field.</td>
<td>Pupils discuss how they would find their way out of a forest/jungle if they were lost.</td>
<td>Show video clip of ship's navigation system or orienteering.</td>
<td>Demonstration of magnetic shielding.</td>
</tr>
</tbody>
</table>

Recap last lesson

- Pupils answer questions on an OHT based on the last lesson.
- Discussion of answers by whole class.

Share learning objectives

- Ask pupils to write a list of FAQs they would put on a website telling people about the Earth's magnetic field. Collect suggestions as a whole-class activity, steering pupils towards those related to the objectives. Conclude by highlighting the questions you want them to be able to answer at the end of the lesson.

Problem solving

- Pupils, working in groups, discuss how they could find their way out of a forest/jungle if they had lost their way.
- One pupil from each group then reports back to the whole class.

Capture interest (1)

- Show a video clip of a ship's navigation system or orienteering.
- Discuss with pupils how a compass works.

Capture interest (2)

- Set up the equipment as shown in the diagram. Place various materials between the magnet and the paper clip on a thread. Some materials allow the magnetic field to pass through them; others do not, and the paper clip drops.
- Pupils can make a list of the materials that allow the magnetic field to pass through them and those that do not.
- They can then be asked if they notice anything about the materials that do not allow the magnetic field to pass through. The pupils should notice that these are all magnetic materials. The effect is known as magnetic shielding.

Equipment

- Magnet, clamp stand (to hold magnet vertically), thread, blu tack, paper clip, various materials to test, e.g. iron, paper, aluminium, glass
Recap last lesson

What materials are attracted to a magnet?

What happens if you bring the north poles of two magnets together?

What happens if you bring the north and south poles of two magnets together?

What is a magnetic field?

Sketch the magnetic field around a bar magnet.

How can you test for a magnet?
Making magnets

Suggested alternative starter activities (5-10 minutes)

<table>
<thead>
<tr>
<th>Recap last lesson</th>
<th>Share learning objectives</th>
<th>Problem solving</th>
<th>Capture interest (1)</th>
<th>Capture interest (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils talk for 1 minute about the Earth’s magnetic field.</td>
<td>- Find out what happens when something is magnetised.</td>
<td>Pupils discuss how cans made from different materials could be separated.</td>
<td>Animation showing particles in a piece of iron or steel gradually lining up as the sample is stroked with a bar magnet.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Find out about a theory of magnetism. (Red only)</td>
<td></td>
<td></td>
<td>Catalyst Interactive Presentations 2</td>
</tr>
<tr>
<td></td>
<td>- Be able to make a magnet by the stroking method. (Sc1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Recap last lesson

- A volunteer pupil talks for one minute about the Earth’s magnetic field. Another pupil continues if necessary until the key points have been made.
- This idea can be repeated to elicit the key points about using a compass for navigation, if time allows.

Share learning objectives

- Ask pupils to write a list of FAQs they would put on a website telling people about what happens when a material is magnetised. Collect suggestions as a whole-class activity, steering pupils towards those related to the objectives. Conclude by highlighting the questions you want them to be able to answer at the end of the lesson.

Problem solving

- Show the class a selection of metal cans made from aluminium, steel, etc. (Some cans are marked with a recycling logo.)
- The class discusses, in small groups, how the different materials can be separated and suggests an automatic procedure that could be used by a recycling company.
- Some groups, depending on the time available, report back to the class.
- Demonstrate the separation of cans made from magnetic and non-magnetic materials.

Capture interest (1)

- Demonstrate the alignment of groups of particles, or domains, by stroking a tube of iron filings.
- Introduce the idea of magnetic domains (Red only).

Capture interest (2)

- Pupils are shown an animation demonstrating the behaviour of the particles in a piece of iron or steel gradually lining up as the sample is stroked with a bar magnet.

Equipment

- Test-tube two-thirds full of iron filings fitted with a tight stopper,
- Strong bar magnet,
- Small nails or pins to test that a magnet has been made
J4 Electromagnets

Recap last lesson
- Pupils work in groups to think of five things that must be remembered when making a magnet, as they did in the previous lesson.
- Each group nominates one pupil to report back to the class. (There may not be time, or it may prove repetitive, for all groups to report back.)
- Relevant points could be written on the board or OHT as they are mentioned or the points (right) put on a prepared OHT displayed at the end of the Starter.

Share learning objectives
Ask pupils to write a list of FAQs they would put on a website telling people about electromagnets. Collect suggestions as a whole-class activity, steering pupils towards those related to the objectives. Conclude by highlighting the questions you want them to be able to answer at the end of the lesson.

Capture interest (1)
- Demonstrate the use of a solenoid around a steel core to make a magnet electrically.
- Invite suggestions about the shape of the magnetic field pattern around the solenoid.

Capture interest (2)
- Pupils watch a video clip of electromagnets being used; e.g. to move cars around in a scrap yard, remove a ferrous object from the eye, in an MRI scanner.

Capture interest (3)
- Pupils see a demonstration of an electromagnet used to move a ferrous object from A to B, showing it only works when the current is switched on.
- Demonstrate some examples of electromagnets, e.g. electric bell or buzzer, relay.

Suggested alternative starter activities (5-10 minutes)

<table>
<thead>
<tr>
<th>Recap last lesson</th>
<th>Share learning objectives</th>
<th>Capture interest (1)</th>
<th>Capture interest (2)</th>
<th>Capture interest (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils think of five important things to remember when making magnets.</td>
<td>- Find out about the magnetic field due to a solenoid.</td>
<td>Demonstration of how to make a magnet using an electric current.</td>
<td>Show video clips of electromagnets being used.</td>
<td>Demonstration of an electromagnet used to move a toy car and some things that use an electromagnet, e.g. electric bell, buzzer, relay.</td>
</tr>
</tbody>
</table>

Answers
Five from:
- The material chosen to make the magnet must be a magnetic material.
- To make a permanent magnet steel should be used.
- A strong bar magnet should be used for stroking.
- The object to be made into a magnet must be stroked several times (until all the particles (or domains) are fully aligned).
- The object must always be stroked in the same direction.
- The polarity of the new magnet depends on the pole used to stroke it.
- The new magnet should be tested to check it has been magnetised.

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Electromagnets

Capture interest (1)

Technician sheet
Supply the following for a demonstration of making a magnet electrically.
- solenoid (coil of wire)
- iron or steel cylindrical core
- low-voltage, high-current power supply (e.g. Westminster type)
- two crocodile clips
- nails or pins (to check that the core is magnetised)

The apparatus should be assembled as in the diagram.

Capture interest (3)
1. Supply the following for a demonstration of using an electromagnet to move a ferrous object from A to B.
   - solenoid (coil of wire)
   - cylindrical iron core (preferably of large diameter)
   - low-voltage, high-current power supply (e.g. Westminster type)
   - two crocodile clips
   - suitable ferrous object to move across bench (e.g. toy car)

2. Set up one or two examples of electromagnets being used, for example:
   - an electric bell or buzzer connected to a suitable power supply
   - a relay being used to switch on a motor remotely.
**Suggested alternative starter activities** (5–10 minutes)

<table>
<thead>
<tr>
<th>Bridging to the unit</th>
<th>Setting the context</th>
<th>Concrete preparation (1)</th>
<th>Concrete preparation (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate weak and strong electromagnets and/or show video clips of weak and strong electromagnets being used.</td>
<td>Pupils arrange sentences about how to make an electromagnet in a logical sequence.</td>
<td>Teacher-led discussion on the meaning of input and outcome variables and the need to control variables to ensure a fair test.</td>
<td>Teacher-led discussion on how to analyse results.</td>
</tr>
</tbody>
</table>

### Bridging to the unit

- A demonstration to show that different strengths of electromagnet are required for different purposes.
- This can be supplemented, or replaced, by video clips showing electromagnets being used to pick up (i) very tiny and (ii) very large magnetic objects.

### Setting the context

- Pupils rearrange a series of sentences in the correct order to explain how to make an electromagnet. The pupil sheet can be used as an OHT.

### Concrete preparation (1)

- A teacher-led discussion on the meaning of input/independent and outcome/dependent variables and the need to control variables is designed to remind pupils of one of the key ideas to be addressed in this lesson.
- At the end of the discussion pupils should know that:
  - an input variable is something that you change
  - an outcome variable is something that you measure
  - variables need to be controlled carefully in order to ensure a fair test.

### Concrete preparation (2)

- Teacher-led discussion on how to analyse results using line graphs, charts, etc. This is the other key idea to be addressed in this lesson.
- Pupils should be reminded that a chart or graph should always be used, if possible, to present results of experimental work.
- At the end of the discussion pupils should know that:
  - it is important to look for relationships
  - a line graph should be drawn when there is a continuous variable
  - a bar graph or other type of chart should be drawn when there is a discrete variable.
Setting the context

Rearrange the sentences in the correct order so that they explain how to make an electromagnet.

A Attach a crocodile clip to each of the stripped ends.

B Take about 1 m of insulated wire and a cylindrical iron rod.

C Use two connecting leads to join the crocodile clips to a power supply.

D Wind the insulated wire around the iron rod many times, leaving about 20 cm of wire free at either end.

E Strip the insulation from about 1 cm of wire at either end of the coil.
**Investigate: How to make an electromagnet stronger**

**Suggested alternative starter activities (5–10 minutes)**

<table>
<thead>
<tr>
<th>Setting the context</th>
<th>Introduce the apparatus</th>
<th>Safety</th>
<th>Brainstorming (1)</th>
<th>Brainstorming (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss the uses of an electromagnet and the need to be able to vary its strength.</td>
<td>Pupils discuss the basic apparatus that could be used to make an electromagnet and vary its strength.</td>
<td>Pupils discuss the hazards of the investigation and the steps they must take to ensure their safety.</td>
<td>Pupils discuss the variables in the investigation and how to control the other variables to ensure a fair test.</td>
<td>Pupils brainstorm ways of measuring the strength of the electromagnet.</td>
</tr>
</tbody>
</table>

**Setting the context**
- Discuss the uses of electromagnets and the need to be able to vary their strength.

**Introduce the apparatus**
- Groups of pupils discuss the basic apparatus that could be used to make an electromagnet and vary its strength. They report back to the class.
- Add further suggestions as necessary and show pupils the equipment that is available.

**Safety**
- Ask pupils to work in pairs to list the hazards involved in this investigation.
- Pupils then decide how to minimise the danger presented by each hazard.
- Pairs report back to a class discussion during which a final set of safety procedures is listed on the board.

**Brainstorming (1)**
- Ask pupils to discuss in groups what the variables are in the investigation.
- Ask them to decide what variable should be changed (input/independent variable) and what should be measured during the investigation (outcome/dependent variable).
- Ask individual pupils for their ideas.
- Use class discussion to finalise details of the two outcome/dependent variables.

**Brainstorming (2)**
- Ask pupils to discuss in groups how the strength of the electromagnet could be measured.
- Selected pupils give their suggestions as a basis for discussion.

Possible methods:
- Counting the number of paper clips/pins/nails picked up by the electromagnet.
- Weighing the amount of small magnetic particles (washers, nuts or similar) picked up by the electromagnet. (Iron filings should be avoided for safety and practical reasons.)
- Measuring the force required to separate the electromagnet from a piece of iron or steel.

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What do magnets do?

### Running the activity
Pupils work in small groups. They are provided with one (Help) or two (Core) bar magnets, a selection of different materials, some of which are magnetic, and a plotting compass.

**Core:**
- Pupils follow the instructions on the sheet, record their observations and answer the questions set throughout the sheet. They finish by selecting and writing down the true statements from a collection of eleven.

**Help:**
- A fill-in results table is provided and the tasks are presented in a structured way.

### Expected outcomes
- All pupils should be able to identify iron and nickel as magnetic materials.
- Core: They should also discover the law of magnetic poles – ‘like poles repel, unlike poles attract’.
- Help: The Help sheet only covers the work on magnetic materials but pupils who complete this quickly should proceed to parts 3 and 4 of the Core sheet instructions.

### Pitfalls
Make sure that the small plotting compasses have not been demagnetised or remagnetised with the opposite polarity.

### ICT opportunities
It would be possible to set up a spreadsheet for the results.

### Answers
**Core:**
1. Iron, nickel.
2. S pole of compass moves towards N pole of magnet, and vice versa.
3. N and S attract; N and N or S and S repel.
4. Correct statements are:
   - Iron sticks to a magnet.
   - Nickel sticks to a magnet.
   - Iron and nickel are magnetic materials.
   - Compasses point towards one end (pole) of the magnet and away from the other end (pole) of the magnet.
   - Same poles repel.
   - Unlike poles attract.

**Help:**
1. Answers will vary.
2. Iron, steel, nickel, cobalt and iron oxide are the only materials attracted to a magnet.
### What do magnets do?

#### Equipment
- For each group:
  - 2 bar magnets
  - Small pieces of iron, nickel, copper, and aluminium
  - A compass

#### For your information

**Running the activity**
Pupils work in small groups. They are provided with one (Help) or two (Core) bar magnets, a selection of different materials, some of which are magnetic, and a plotting compass.

Core: Pupils follow the instructions on the sheet, record their observations and answer the questions set throughout the sheet. They finish by selecting and writing down the true statements from a collection of eleven.

Help: A fill-in results table is provided and the tasks are presented in a structured way.

**Expected outcomes**
All pupils should be able to identify iron and nickel as magnetic materials.

Core: They should also discover the law of magnetic poles – ‘like poles repel, unlike poles attract’.

Help: The Help sheet only covers the work on magnetic materials but pupils who complete this quickly should proceed to parts 3 and 4 of the Core sheet instructions.

**Pitfalls**
Make sure that the small plotting compasses have not been demagnetised or remagnetised with the opposite polarity.
What do magnets do?

You are going to find out which metals are magnetic and see how magnets behave.

Equipment
- 2 bar magnets
- small pieces of iron, nickel, copper and aluminium
- a compass

Obtaining evidence
1. Try picking up each metal with a magnet.
   1. Which metals are magnetic materials?
2. Put the compass near a magnet.
   2. What happens?
Magnets have two ends. The ends are called poles.
3. Try pushing two magnets together at the ends (the poles).
   3. What happens?
4. Turn one of the magnets around. Try pushing the two magnets together.
   4. What happens?

Considering the evidence and evaluating
5. Look at these statements about magnets. Pick out the correct ones and write them down.

- Aluminium sticks to a magnet.
- Iron sticks to a magnet.
- Nickel sticks to a magnet.
- Unlike poles repel.
- Copper sticks to a magnet.
- Iron and nickel are magnetic materials.
- Unlike poles attract.
- Same poles attract.
- Compasses always point to the Earth's north pole, even if they are close to a magnet.
- Same poles repel.
- Compasses point towards one end (pole) of the magnet and away from the other end (pole) of the magnet.
What do magnets do?

You are going to find out what materials are attracted to a magnet; these materials are called magnetic.

Equipment

- a selection of materials, each labelled so that you know what it is made from
- bar magnet

Predicting

1. Write the name of each material in the table below.
2. In the second column in the table below predict whether each material will be magnetic or non-magnetic.

<table>
<thead>
<tr>
<th>Material</th>
<th>Prediction</th>
<th>Magnetic? (write yes or no)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Obtaining evidence

3. Now test the materials to see which are attracted to a magnet. Write the results in the last column of the table.

1. How good were your predictions? If some were not correct, try to think why your results were different from your predictions.
2. Write down any pattern you observe.
Magnetic forces

Running the activity

Pupils work in small groups. They are provided with four bar magnets of varying strengths, labelled A, B, C and D. Their task is to find out about the forces between pairs of magnets.

Core: Pupils follow the instructions on the sheet, record their observations and answer the questions set throughout the sheet. They finish by listing the similarities and differences in the forces between various pairs of magnets.

Help: A fill-in results table is provided and the tasks are presented in a structured way.

Extension: Pupils attempt to solve a practical problem. They plan and carry out an experiment to identify four rods, all of similar appearance, using only a bar magnet.

Expected outcomes

All pupils should realise that magnets can push and pull without touching.

Core: They should also be able to use the rule ‘like poles repel, unlike poles attract’ to predict the nature of the force between two magnets.

Help: The Help sheet has the same outcome but pupils are given clear, precise instructions at each stage of the activity.

Extension: Pupils identify the four rods using their knowledge of magnetic behaviour and an understanding of density. The magnet can be identified as it is the only rod that exhibits repulsion when brought near to the given magnet. The iron rod will be attracted to both ends of the magnet. The other two rods are unaffected by the magnet but can be identified as wood has a much lower density than brass.

Pitfalls

Some students may find it hard to distinguish between attraction (pulling force) and repulsion (pushing force).

ICT opportunities

It would be possible to set up a spreadsheet for the results.

Answers

Core:

1. Yes, a push.
2. At the ends.
3. Yes, a pull.
4. Unlike poles attract, like poles repel.
5. Push and pull forces exist as before, forces strongest at the ends (poles).
6. Forces between C and D weaker than those between A and B; A and C of unequal strength.

Extension:

1. Suspend each rod by a thread, in turn. The magnet will set in a N-S direction. This rod can then be used to identify the iron rod. The brass and wood rods are distinguished as before.

Help:

1. Yes, push.
2. Ends
3. Yes, pull.
4. Repel, attract.
5. NN, pushing force, ends, smaller NS, pulling force, ends, smaller.
Magnetic forces

For each group:
- Core, Help:
  - selection of magnets labelled A, B, C and D
    (A and B should both be ‘strong’ magnets; C and D should be weaker than A and B.)
  - Extension:
    - four similar rods, labelled W, X, Y and Z, made of iron, brass, wood and a magnet
    - bar magnet

For your information

Running the activity

Pupils work in small groups. They are provided with four bar magnets of varying strengths, labelled A, B, C and D. Their task is to find out about the forces between pairs of magnets.

Core:
- Pupils follow the instructions on the sheet, record their observations and answer the questions set throughout the sheet. They finish by listing the similarities and differences in the forces between various pairs of magnets.

Help:
- A fill-in results table is provided and the tasks are presented in a structured way.

Extension:
- Pupils attempt to solve a practical problem. They plan and carry out an experiment to identify four rods, all of similar appearance, using only a bar magnet.

Expected outcomes

All pupils should realise that magnets can push and pull without touching.

Core:
- They should also be able to use the rule ‘like poles repel, unlike poles attract’ to predict the nature of the force between two magnets.

Help:
- The Help sheet has the same outcome but pupils are given clear, precise instructions at each stage of the activity.

Extension:
- Pupils identify the four rods using their knowledge of magnetic behaviour and an understanding of density. The magnet can be identified as it is the only rod that exhibits repulsion when brought near to the given magnet. The iron rod will be attracted to both ends of the magnet. The other two rods are unaffected by the magnet but can be identified as wood has a much lower density than brass.

Pitfalls

Some students may find it hard to distinguish between attraction (pulling force) and repulsion (pushing force).
You are going to investigate the forces between magnets. When magnets are close together there is a force between them. Sometimes this is a pushing apart force and sometimes a pulling together force.

**Equipment**
- selection of magnets, labelled A, B, C and D

**Obtaining evidence**

1. Place magnets A and B near each other on the table so that the ends marked N are opposite each other.
2. Move the magnets to see where the forces are strongest.
3. Turn magnet B around so that the end marked S is opposite the end marked N on magnet A.
4. Write down a rule for the forces between magnets using the words ‘attract’ and ‘repel’.
5. Write down as many things as you can about the forces between the magnets that were the same as the forces between magnets A and B.
6. Write down as many things as you can about the forces between the magnets that were different to the forces between magnets A and B.
You are going to investigate the forces between magnets.

1. Follow the practical instructions 1-3 given on the Core sheet J1b but answer the questions on this sheet.

   Circle the correct answer in questions 1 to 3.

   1. Is there a force between magnets A and B? yes no
      Is it a push or a pull? push pull

   2. Where are the forces strongest? ends middle

   3. Is there a force between A and B when you turn magnet B around? yes no
      Is it a push or a pull? push pull

4. Complete the rule for the forces between magnets using the words ‘attract’ and ‘repel’.
   When the same ends of the magnets are near each other they ....................
   When different ends of the magnets are near each other they ....................

2. Test the forces between magnets C and D (i) with the two N ends opposite and (ii) with N and S ends opposite.

5. Fill in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Pulling or pushing force?</th>
<th>Force strongest at ends or middle?</th>
<th>Force bigger or smaller than A and B?</th>
</tr>
</thead>
<tbody>
<tr>
<td>NN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Magnetic forces

You have been given four rods, all of similar appearance, and a bar magnet. One of the rods is made from iron, one from brass and one from wood, and the other is a magnet. Your task is to identify the four rods.

Equipment

- four similar rods, labelled W, X, Y and Z
- bar magnet
- thread (optional)

Planning

1. Write down what you will do to identify each rod.
2. Say what you expect to happen.

Obtaining evidence

3. Carry out your planned practical work.
4. Write down any changes you made to your plan and explain why they were necessary.

Presenting the results

Identify the four rods, W, X, Y and Z.

1. Suggest how you could have identified the four rods without the help of another magnet.
Plotting magnetic fields

Running the activity

Core: Pupils use a small plotting compass to plot the magnetic field due to a bar magnet.

Extension: The method is extended to plot the magnetic field patterns for two bar magnets (i) with unlike poles adjacent (ii) with like poles adjacent.

Expected outcomes

Core: Pupils plot the magnetic field due to a bar magnet and add arrows to show the direction of the magnetic field from N to S.

Extension: Some pupils extend the method of plotting magnetic fields to plot the magnetic field due to two magnets placed parallel to each other:
(i) with a N and a S pole opposite each other
(ii) with the two N poles and the two S poles opposite each other.
This leads to an understanding of the idea of a neutral point.

Pitfalls

The apparatus must be positioned well away from any other magnets.

Answers

Core:
1. The N pole of the plotting compass is attracted to the S pole of the bar magnet.
2. Near the ends of the magnet. This tells us that the magnetic field is strongest there.

Extension:
1. N and S attract but N and N repel.
2. The compass needle does not set in any direction.
3. The same as with two N poles but in the opposite direction.
4. (i) (ii)

<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose</th>
<th>Differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical</td>
<td>Pupils use a small plotting compass to show the pattern of the magnetic field of a bar magnet.</td>
<td>Core, Extension</td>
</tr>
</tbody>
</table>
Plotting magnetic fields

**Equipment**

For each group:
- bar magnet (two for each Extension group)
- plotting compass
- A4 sheet of plain paper
- sharp, soft pencil

**For your information**

**Running the activity**

Core: Pupils use a small plotting compass to show the pattern of the magnetic field of a bar magnet.

Extension: The method is extended to plot the magnetic field patterns for two bar magnets (i) with unlike poles adjacent (ii) with like poles adjacent.

**Expected outcomes**

Core: Pupils plot the magnetic field due to a bar magnet and add arrows to show the direction of the magnetic field from N to S.

Extension: Some pupils extend the method of plotting magnetic fields to plot the magnetic field due to two magnets placed parallel to each other:
(i) with a N and a S pole opposite each other
(ii) with the two N poles and the two S poles opposite each other.
This leads to an understanding of the idea of a neutral point.

**Pitfalls**

The apparatus must be positioned well away from any other magnets.
Plotting magnetic fields

You are going to use a small plotting compass to show the pattern of the magnetic field of a bar magnet.

Equipment

- bar magnet
- A4 sheet of plain paper
- plotting compass
- sharp, soft pencil

Obtaining evidence

1. Place your magnet in the middle of a sheet of plain paper and draw round it.
2. Remove the magnet and mark where the N pole goes with a letter N.
3. Put the magnet back on the paper and draw a dot at the top right-hand corner of the magnet.
4. Put the plotting compass next to the dot you have drawn so that the needle points away from the dot.
5. Draw a dot on the paper at the other end of the compass needle.
6. Move the compass along so that it now points away from the dot you have just drawn.
7. Keep doing this until you come back to the magnet or reach the edge of the paper.
8. Remove the magnet and join the dots with a thin, smooth pencil line. Put an arrow on the line to show which way the N pole of the plotting compass pointed.

1. Why do you think the compass pointed in this direction?
9. Put the magnet back again. Start at the bottom right-hand corner of the magnet this time and repeat steps 3 to 8.
10. Carry on plotting as many magnetic field lines as you can in the time allowed for this activity. Try to do the same on both sides of the magnet.

2. Where are the magnetic field lines closest together? Suggest what this tells us about the strength of the magnetic field.
Plotting magnetic fields with two magnets

You are going to extend the idea of plotting magnetic fields with a plotting compass to see what happens when you use two magnets.

Equipment
- two bar magnets
- plotting compass
- A4 sheet of plain paper
- sharp, soft pencil

Obtaining evidence

1. Place the bar magnets side by side on a sheet of paper with about 10 cm between them and N and S poles next to each other.
2. Plot the magnetic field pattern in the space between the magnets using a plotting compass as before.
3. Repeat with the two N poles next to each other.
4. Why do you think the two patterns are different?

1. What do you notice? This point is called a neutral point.
2. What do you think the pattern would be if the two S poles were placed next to each other?
3. Sketch the magnetic field pattern you would expect if the two bar magnets were placed parallel to each other
   (i) with a N pole and a S pole opposite each other (as in the diagram),
   (ii) with the two N poles and the two S poles opposite each other.

If you have time you can plot these magnetic field patterns using a plotting compass and compare your results with your sketches.
Using a compass to navigate

Running the activity

This activity is best carried out in small groups. It allows pupils to test how well a compass works over short distances. If weather permits it can be carried out outside, but if this is not possible a large room such as an assembly hall could be used. Interest can be maintained as each group navigates the course by having a competition to see which group gets closest to the treasure. Alternatively, the rest of the class can be engaged in another activity while each group walks the course in turn.

The teacher (or technician) needs to produce a map/diagram showing the location of the ‘treasure’ and a route from the starting point. The first direction travelled should be north and the second east, to agree with the instructions on the Core sheet. It is best to plot a course using only right angle or 45 degree turns.

Expected outcomes

With care, pupils should be able to get quite close to the location of the treasure.

Pitfalls

Care is needed in setting the compass, walking in the exact direction and measuring the distance accurately if the experiment is to work properly.

Answers

1. Individual answer for each group.
2. Individual answer for each class.
3. Setting the direction accurately using the compass; walking in the precise direction of the compass; measuring distances accurately.
4. The error becomes greater the greater the distance travelled and the more changes in direction involved. If the group is 1 m out in travelling 10 m it would be 100 m out if it travelled 1 km, so the group would be very likely to get lost! This could be very dangerous in hostile or remote areas or when it is foggy.
Using a compass to navigate

**Type**
- Practical

**Purpose**
- Pupils work in groups using a compass to navigate a route to find some hidden treasure. There can be a competition to see which group gets closest to the treasure.

**Differentiation**
- Core

**Equipment**
For each group:
- map showing location of buried treasure and planned route
- chalk, tape or small object to indicate the starting point
- orienteering compass
- trundle wheel or measuring tape
- stick (or similar) with group name to mark position of treasure

**For your information**
The teacher (or technician) needs to produce a map/diagram showing the location of the ‘treasure’ and a route from the starting point. The first direction travelled should be north and the second east, to agree with the instructions on the Core sheet. It is best to plot a course using only right angle or 45 degree turns. The complexity of the course should reflect the ability of the pupils.

**Running the activity**
This activity is best carried out in small groups. It allows pupils to test how well a compass works over short distances. If weather permits it can be carried out outside, but if this is not possible a large room such as an assembly hall could be used. Interest can be maintained as each group navigates the course by having a competition to see which group gets closest to the treasure. Alternatively, the rest of the class can be engaged in another activity while each group walks the course in turn.

**Expected outcomes**
With care, pupils should be able to get quite close to the location of the treasure.

**Pitfalls**
Care is needed in setting the compass, walking in the exact direction and measuring the distance accurately if the experiment is to work properly.
Using a compass to navigate

The invention of the compass allowed people to find their way around more safely. Working in groups you are going to use a compass to navigate a route to find some hidden treasure. There is a competition to see which group gets closest to the treasure.

Equipment

- map showing location of buried treasure and planned route
- orienteering compass
- trundle wheel or measuring tape
- stick (or similar) with group name to mark position of treasure

Navigating

1. Go to the starting post marked on your map.
2. Turn the compass ring so that N lines up with the direction of travel arrow. Turn round with the compass until the needle lines up with the north arrow on the compass.
3. Walk the distance indicated on the map. (You need to measure this distance as accurately as you can.)
4. Set the compass ring to east. Turn with the compass until the needle lines up with the north arrow. Walk the distance indicated on the map as before.
5. Repeat until you arrive at the point where the treasure is hidden. Mark the spot with your named stick.

Considering the evidence

① How close were you to the hidden treasure?
② How close was the winning group to the hidden treasure?

Evaluating

③ What were the main sources of error?
④ Do you think you could navigate over longer distances by this method? Would the possible error be acceptable or would you be likely to get lost?
Teacher activity notes

William Gilbert

Running the activity

Pupils are given a set time to find out as much as they can about William Gilbert. The pupil sheet poses some key questions to which they should seek answers, but the task is sufficiently open-ended to challenge the most able pupils.

Pupils are advised to save the information they obtain in Microsoft® Word® computer files, ready for use when producing their final document.

The pupil sheet leaves pupils to decide how to present the information gained, but teachers can be more specific if they wish. Each pupil, or group of pupils, could produce a poster, a booklet or similar. If time permits each group could give a Microsoft® PowerPoint® presentation. The class could then vote for the best one.

Other relevant material

Websearch. Suitable sites could be given to pupils initially or used if required later.

BBC History: William Gilbert

More information on William Gilbert

Pitfalls

An overabundance of information may lead pupils to produce a report that is too long. Pupils should be encouraged to be selective when planning their report and to use the information they have obtained to inform their own work. Pupils should not copy long excerpts from their research material.
You are going use books and the Internet to find out about William Gilbert, who discovered that the Earth is magnetic.

Obtaining information

1. Find out as much as you can about William Gilbert. Your teacher will tell you how much time you have to do this. You may find it best to save what you find out in Word® computer files.

2. Try to find out the answers to these questions.

   - Who was William Gilbert?
   - When did he live?
   - What was his profession?
   - What did he discover about the Earth and magnetism?
   - Why was this very important?

Presenting the results

Decide how you are going to present your information. Your teacher may give you some guidance on this.
Making magnets

**Running the activity**

Core: Pupils discuss how they will measure the strength of the magnet they plan to make by stroking a steel strip with a bar magnet. Working in groups, they should perform the experiment several times to get average readings. More consistent results are obtained if the magnetised steel strip is always held in the same position with respect to the paper clips.

Help: Pupils make a model magnet by stroking a test-tube of iron filings with a bar magnet. They stroke it several times and check that it is magnetised. They shake the test-tube to demagnetise the model magnet (and check that it is demagnetised).

More able pupils may have time to compare results using a stronger or weaker magnet than used initially or pupils can be given magnets of different strengths so that they can compare their results.

**Expected outcomes**

Pupils understand that a magnet can be made by stroking a magnetic material with a bar magnet.

Core: Pupils realise that there is a limit to the strength of the magnet they can make.

Help: Pupils understand that a magnet is made by aligning the iron filings in the test-tube. (They may need to be reminded that repulsion is the only test for a magnet.)

**Pitfalls**

Pupils often fail to understand that the stroking action must always be carried out in the same direction. If a large circular action is demonstrated pupils are less likely to move the magnet backwards and forwards, failing to magnetise the steel strip or test-tube of iron filings.

**Safety notes**

Core: Make sure the steel strip has no sharp edges.

Help: Pupils only need eye protection if the iron filings are used loose. If the bung comes off the test-tube or the test-tube breaks, try to ensure that pupils do not touch the iron filings. If they do, they must wash their hands thoroughly.

**ICT opportunities**

It would be possible to set up a spreadsheet for the results and to plot a graph.

**Answers**

Core:

1. The more times the steel strip is stroked the stronger the magnet. The strength should increase with the number of strokes, but only up to a limit (when all the domains are aligned).
Making magnets (continued)

2. Plot a graph of the number of paper clips attracted against the number of strokes.

3. Comparison with other groups: Results may differ if the stroking magnets are of varying strengths or the range of stroke numbers differs.

4. Answers will vary.

5. Alternative methods: e.g. using smaller objects than paper clips (the mass attracted could be found rather than counting the number attracted if they are very small) or the force needed to separate the magnet from a piece of iron could be measured with a forcemeter.

Help:

1. The iron filings line up.

2. Each iron filing becomes a tiny magnet, so when lined up one end has free N poles and the other S poles.

3. Yes, but only up to a limit as once the iron filings are fully aligned the magnet cannot be made any stronger.

4. (i) randomly, (ii) lined up/all pointing in the same direction.
Making magnets

**Equipment**

For each group:
- Core: Help:
  - steel strip
  - bar magnet (possibly different strengths for different groups)
  - paper clips
  - access to a demagnetising coil
  - carrying alternating current

- Carrying alternating current (to test for magnetism)

**For your information**

**Running the activity**

Core: Pupils discuss how they will measure the strength of the magnet they plan to make by stroking a steel strip with a bar magnet. Working in groups, they should perform the experiment several times to get average readings. More consistent results are obtained if the magnetised steel strip is always held in the same position with respect to the paper clips.

Help: Pupils make a model magnet by stroking a test-tube of iron filings with a bar magnet. They stroke it several times and check that it is magnetised. They shake the test-tube to demagnetise the model magnet (and check that it is demagnetised).

More able pupils may have time to compare results using a stronger or weaker magnet than used initially or pupils can be given magnets of different strengths so that they can compare their results.

**Expected outcomes**

Pupils understand that a magnet can be made by stroking a magnetic material with a bar magnet.

Core: Pupils realise that there is a limit to the strength of the magnet they can make.

Help: Pupils understand that a magnet is made by aligning the iron filings in the test-tube. (They may need to be reminded that repulsion is the only test for a magnet.)

**Pitfalls**

Pupils often fail to understand that the stroking action must always be carried out in the same direction. If a large circular action is demonstrated pupils are less likely to move the magnet backwards and forwards, failing to magnetise the steel strip or test-tube of iron filings.

**Safety notes**

Core: Make sure the steel strip has no sharp edges.

Help: Pupils only need eye protection if the iron filings are used loose. If the bung comes off the test-tube or the test-tube breaks, try to ensure that pupils do not touch the iron filings. If they do, they must wash their hands thoroughly.

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This worksheet may have been altered from the original on the CD-ROM.

Sheet 1 of 1
Making magnets

You are going to make a magnet from a steel strip by stroking it with a bar magnet and test its strength.

Equipment

- steel strip
- paper clips
- bar magnet
- access to a demagnetising coil carrying alternating current

Planning and predicting

1. Decide how to arrange the paper clips so that you can test the strength of the magnet you have made.
2. Decide how to stroke the steel strip and how many times to do it.
3. Decide whether to test its strength each time you stroke it or after a certain number of strokes. Draw up a table to record your results. You could use one like this.

<table>
<thead>
<tr>
<th>Number of strokes</th>
<th>Number of paper clips picked up</th>
</tr>
</thead>
</table>

Obtaining evidence

4. Stroke the steel strip with the magnet and test its strength by seeing how many paper clips it can pick up. Record your result in your table.
5. Demagnetise the steel strip completely using a demagnetising coil. (Your teacher will show you how to do this.)
6. Now stroke the steel strip a different number of times. Test its strength and record your result. Demagnetise it as before.
7. Repeat this procedure several more times.

Considering the evidence

1. Did the number of times you stroked the steel strip have any effect on the strength of the magnet you made? Is there a pattern in your results?
2. If you have time, draw a graph to show your results. (What would you plot on each axis?)
3. Compare your results with other groups. Are their results different? If they are, can you suggest why?

Evaluating

4. Do you think this was the best method of testing the strength of the magnet you made?
5. Can you think of other ways of testing the strength of the magnet? Would these ways have been more accurate?
You are going to make a model bar magnet using a test-tube of iron filings.

Equipment
- test-tube of iron filings with a tight-fitting bung (do not remove the bung)
- strong bar magnet
- plotting compass (to test for magnetism)

Obtaining evidence
1. Shake the tube carefully to mix the iron filings.
2. Use the plotting compass to check that the test-tube is not magnetised. (Both ends of the test-tube should attract the needle of the plotting compass.)
3. Stroke the test-tube, always in the same direction, with one pole of the magnet. Watch the iron filings.
4. Check that the test-tube is magnetised. (One end of the test-tube should repel the compass needle.)

Considering the evidence
1. What happens to the iron filings as the test-tube is stroked?
2. How does this magnetise the test-tube?
3. Do you think the test-tube would become more strongly magnetised if you kept stroking it for a long time? Explain your answer.

The iron filings behave just like groups of particles in an iron bar.

4. How do you think the domains are arranged when the iron bar is
   (i) unmagnetised and (ii) magnetised?
Making a compass

Running the activity
Pupils magnetise a blunt needle or straightened paper clip. They then: (i) suspend it by a thread and (ii) float it on water. The two methods are then evaluated.

Expected outcomes
The magnetised needle (or paper clip) should settle in a north–south direction each time.

Pitfalls
When suspended by a thread the needle (or paper clip) takes time to settle but should point roughly north depending on the twist in the thread. The needle (or paper clip) must be placed on a piece of filter paper and lowered very carefully onto the water if it is not to sink. A needle is better for this.

Check that there are no magnetic materials near as this would affect the Earth’s field. If a compass is used to check which way the needle is pointing it must not be brought close to the needle!

Safety notes
Make sure the ends of the needles or paper clips are not sharp or pointed.

Answers
1. north–south
2. north–south
3. Answers will vary as not all pupils will find the two methods equally easy to set up or equally successful.
4. No. Reasons will vary, e.g. could not carry a dish of water around; twist in thread means suspended needle is not very accurate and takes a long time to settle.
5. Sensible suggestions might include an improved method of suspension or floating the needle in a sealed oil bubble (water would cause rusting).
Making a compass

### Equipment
For each group:
- bar magnet
- blunt needle or straightened paper clip
- length of thread
- filter paper
- trough of water (large enough to float a needle or straightened paper clip)
- compass

### For your information

#### Running the activity
Pupils magnetise a blunt needle or straightened paper clip. They then: (i) suspend it by a thread and (ii) float it on water. The two methods are then evaluated.

#### Expected outcomes
The magnetised needle (or paper clip) should settle in a north–south direction each time.

#### Pitfalls
When suspended by a thread the needle (or paper clip) takes time to settle but should point roughly north depending on the twist in the thread. The needle (or paper clip) must be placed on a piece of filter paper and lowered very carefully onto the water if it is not to sink. A needle is better for this.

Check that there are no magnetic materials near as this would affect the Earth’s field. If a compass is used to check which way the needle is pointing it must not be brought close to the needle!

#### Safety notes
Make sure the ends of the needles or paper clips are not sharp or pointed.

### Table

<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose</th>
<th>Differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical</td>
<td>Pupils try two different ways of making a compass and evaluate them.</td>
<td>Core</td>
</tr>
</tbody>
</table>
Making a compass

You are going to try two ways of making a compass.

**Equipment**
- bar magnet
- blunt needle or straightened paper clip
- length of thread
- filter paper
- trough of water (large enough to float a needle or straightened paper clip)
- compass

**Obtaining evidence**
1. Magnetise the needle (or paper clip) by stroking it several times with the bar magnet.
2. Tie the thread around the centre of the needle (or paper clip) and hold it up so that it can turn freely. Wait for it to stop moving.

(1) Which way does it point? (Use the compass to help you to decide.)

3. Fill the trough with water and wait for the water to stop moving.
4. Place the magnetised needle on a piece of filter paper and carefully lower it onto the surface of the water. The filter paper will sink, leaving the needle floating on the surface of the water. Wait for the needle to stop moving.

(2) Which way does it point? (Use the compass to help you to decide.)

**Evaluating**
3. Which method worked best - letting the needle turn at the end of a thread, or putting it in the water?
4. Could either method be used to find your way around? Explain your answer.
5. How would you improve the design to make a practical compass that could be used for navigation?
Making an electromagnet

Running the activity

A plotting compass is used to plot magnetic field patterns.

Core: A wooden cylinder can be used to form a coil of wire. The magnetic field due to an electric current in the solenoid is plotted.

Extension: The magnetic field due to the current in a very long straight wire is plotted.

Expected outcomes

Core: A magnetic field pattern similar to that around a bar magnet is obtained. Pupils should note that the direction of the magnetic field inside the solenoid is from S to N and is uniform when well within the coil.

Extension: A circular magnetic field is obtained. Pupils should observe that the direction of the magnetic field changes when the current direction is reversed. (The direction can be found using the ‘right hand grip rule’.)

Pitfalls

A large current is needed to obtain a clear pattern, so the wire can get warm. A large current, creating a strong magnetic field, can change the polarity of the plotting compass; it should always be checked before beginning the experiment.

Safety notes

Pupils need to be shown how to use mains operated power supplies safely.

Pupils need to be aware that the wire gets hot when an electric current passes through it.

Pupils must turn off the power supply when they are not taking readings.

Answers

Core:

1. See diagram (right).
2. It is uniform, except near the ends, and goes from S to N.
3. The pattern would be the same shape but the direction of the magnetic field would be reversed.

Extension:

1. Concentric circles.
2. The pattern would be the same shape but the direction of the magnetic field would be reversed.
3. When the current goes down the wire the magnetic field is circular and in a clockwise direction.
   When the current goes up the wire the magnetic field is circular and in an anticlockwise direction.
Making an electromagnet

**Equipment**

For each group:
- about 1 metre of plastic coated wire stripped at both ends
- wooden cylinder (to form a coil of wire)
- low-voltage dc power supply
- two connecting leads
- heat-resistant mat
- plotting compass
- blu tack
- A4 sheet of plain paper

For your information

**Running the activity**

A plotting compass is used to plot magnetic field patterns.

Core: A wooden cylinder can be used to form a coil of wire. The magnetic field due to an electric current in the solenoid is plotted.

Extension: The magnetic field due to the current in a very long straight wire is plotted.

**Expected outcomes**

Core: A magnetic field pattern similar to that around a bar magnet is obtained. Pupils should note that the direction of the magnetic field inside the solenoid is from S to N and is uniform when well within the coil.

Extension: A circular magnetic field is obtained. Pupils should observe that the direction of the magnetic field changes when the current direction is reversed. (The direction can be found using the ‘right hand grip rule’.)

**Pitfalls**

A large current is needed to obtain a clear pattern, so the wire can get warm. A large current, creating a strong magnetic field, can change the polarity of the plotting compass; it should always be checked before beginning the experiment.

**Safety notes**

Pupils need to be shown how to use mains operated power supplies safely.

Pupils need to be aware that the wire gets hot when an electric current passes through it.

Pupils must turn off the power supply when they are not taking readings.
Making an electromagnet

When an electric current passes through a wire a magnetic field is created. You are going to look at the magnetic field due to a current in a solenoid (coil of wire).

Equipment

- about 1 metre of plastic coated wire stripped at both ends
- two connecting leads
- wooden cylinder (to form a coil of wire)
- low-voltage dc power supply
- two crocodile clips
- heat-resistant mat
- plotting compass
- blu tack
- A4 sheet of plain paper

Obtaining evidence

1. Wind the plastic coated wire around the wooden cylinder to form a coil, leaving about 10 cm straight at either end. Remove the wooden cylinder.
2. Place the coil of wire in the middle of the sheet of plain paper, on top of the heat-resistant mat, and fix the coil to the paper using blu tack.
3. Attach the crocodile clips to the bare ends of wire, making sure that the connections are firm. Connect the power supply to the coil using the two connecting leads.
4. Switch on the power supply and use the plotting compass to plot the magnetic field due to the solenoid. Plot the magnetic field inside as well as around the solenoid. Add arrows to show the direction of the magnetic field lines (the direction in which the N pole of the plotting compass points).
   (Remember to switch off the power supply when you have finished.)

Considering the evidence

1. The magnetic field pattern around the solenoid is similar to that around a bar magnet. Draw a bar magnet with this magnetic field pattern, labelling the N and S seeking poles.
2. What do you notice about the magnetic field inside the solenoid?
3. How would your answers to questions 1 and 2 change if the ends of the solenoid were connected to the opposite terminals of the power supply?
When an electric current passes through a wire a magnetic field is created. You are going to look at the magnetic field due to a current in a long straight wire.

**Equipment**
- about 1 metre of plastic coated wire stripped at both ends
- two crocodile clips
- low-voltage dc power supply
- two connecting leads
- plotting compass
- piece of card (about 15 cm square) with central hole
- clamp stand, or similar, to support wire in a vertical position

**Obtaining evidence**

1. Place the wire through the hole in the card and arrange it so that the wire is vertical.
2. Attach the crocodile clips to the bare ends of wire, making sure that the connections are firm. Connect the power supply to the wire using the two connecting leads.
3. Switch on the power supply and use the plotting compass to plot the magnetic field due to the wire. Add arrows to show the direction of the magnetic field lines (the direction in which the N pole of the plotting compass points). (Remember to switch off the power supply when you have finished.)

**Considering the evidence**

1. What shape is the magnetic field?

2. Reverse the connections to the power supply so that the current travels through the wire in the opposite direction. Look at the magnetic field pattern now. (Remember to switch off the power supply when you have finished.)

2. Describe the magnetic field pattern now. How does it differ from the pattern you described in question 1?

3. Write one or two sentences to describe, as fully as you can, the magnetic field due to a current in a long straight wire and how it is related to the direction of the current. (You may find it helpful to use the words ‘clockwise’ and ‘anticlockwise’ in your answer.)
Adding a core to an electromagnet

Running the activity

The strength of an electromagnet may be increased by placing a rod through the centre of the solenoid. Pupils see the effect of using rods made from various materials by seeing how many paper clips or nails can be picked up by each core.

Expected outcomes

Pupils should find that paper clips or nails can only be picked up when the core is made from a magnetic material. Iron is likely to make the strongest electromagnet.

Pupils should observe that an iron core is only magnetised when the current is switched on but a steel core retains its magnetism.

Pitfalls

Make sure that the paper clips or iron nails used to test the strength of the electromagnet are not magnetised before beginning the experiment. Pupils should check that they remain unmagnetised after each reading has been made and demagnetise them if necessary.

Safety notes

Pupils need to be shown how to use mains operated power supplies safely.

Pupils need to be aware that the wire gets hot when an electric current passes through it.

Pupils must turn off the power supply when they are not taking readings.

Answers

1. List of magnetic materials used; e.g. iron, steel.
2. Permanent magnetic materials such as steel will keep their magnetism when the current is switched off. Soft magnetic materials such as iron will not keep their magnetism when the current is switched off.
3. Iron
Adding a core to an electromagnet

**Equipment**

- about 1 metre of plastic coated wire stripped at both ends
- two crocodile clips
- wooden cylinder (to form a coil of wire)
- low-voltage dc power supply
- two connecting leads
- heat-resistant mat
- rods of various materials, as decided by the teacher
- paper clips or iron nails (to test the strength of the electromagnet)
- access to a demagnetising coil carrying alternating current

**For your information**

**Running the activity**

The strength of an electromagnet may be increased by placing a rod through the centre of the solenoid. Pupils see the effect of using rods made from various materials by seeing how many paper clips or nails can be picked up by each core.

**Expected outcomes**

Pupils should find that paper clips or nails can only be picked up when the core is made from a magnetic material. Iron is likely to make the strongest electromagnet. Pupils should observe that an iron core is only magnetised when the current is switched on but a steel core retains its magnetism.

**Pitfalls**

Make sure that the paper clips or iron nails used to test the strength of the electromagnet are not magnetised before beginning the experiment. Pupils should check that they remain unmagnetised after each reading has been made and demagnetise them if necessary.

**Safety notes**

Pupils need to be shown how to use mains operated power supplies safely.

Pupils need to be aware that the wire gets hot when an electric current passes through it.

Pupils must turn off the power supply when they are not taking readings.
Adding a core to an electromagnet

The strength of an electromagnet may be increased by placing a rod through the centre of the solenoid. You are going to see the effect of using rods made from various materials.

Equipment
- about 1 metre of plastic coated wire stripped at both ends
- two crocodile clips
- wooden cylinder (to form a coil of wire)
- low-voltage dc power supply
- two connecting leads
- heat-resistant mat
- rods of various materials, as supplied by your teacher
- paper clips or iron nails (to test the strength of the electromagnet)
- access to a demagnetising coil carrying alternating current

Presenting the results
1. Draw up a table, with two columns headed ‘core material’ and ‘Number of paper clips/nails picked up’ to record your results.

Obtaining evidence
2. Wind the plastic coated wire around the wooden cylinder to form a coil, leaving about 10 cm straight at either end. Remove the wooden cylinder.
3. Attach the crocodile clips to the bare ends of wire, making sure that the connections are firm. Connect the power supply to the coil using the two connecting leads.
4. Check that the paper clips or nails are not magnetised. Use a demagnetising coil if necessary. (Your teacher will show you how to do this.) This should be done after each reading has been made.
5. Switch on the power supply. Count how many paper clips or nails are attracted to the solenoid. Switch off the power supply. Record your result in the table.
6. Place one of the rods inside the solenoid to act as a core. Switch on the power supply. Count how many paper clips or nails are attracted to the solenoid. Switch off the power supply. Record your result in the table as before. Repeat using each core material in turn.

Considering the evidence
1. Which core materials made a difference to the strength of the electromagnet? What word describes these materials?
2. For the core materials you listed in question 1, what happened when the power supply was switched off? (If you cannot remember, do these parts of the experiment again.)
3. Which material made the most difference?
Designing a burglar alarm

<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose</th>
<th>Differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>Pupils are set the task of designing a circuit using a relay to act as a burglar alarm that is activated by opening a window or door.</td>
<td>Extension</td>
</tr>
</tbody>
</table>

Running the activity

The pupil activity sheet provides some background information on relays, together with some questions to test the pupils' understanding before they begin to design the burglar alarm.

ICT opportunities

Pupils could search the Internet for information on how relays are used by the telephone companies. (This would be a suitable extension activity for those pupils who complete the burglar alarm problem very quickly.)

Answers

1. open
2. off
3. ‘Normally closed’ type.
4. ‘Normally open’ type.
5. Close an open window or door.
6. For example: starter motor on a car, security loop to protect expensive goods in a shop, telephone system.
Designing a burglar alarm

A relay is an electromagnetic switch. It uses a circuit containing an electromagnet to switch on another circuit. You are to design a circuit using a relay to act as a burglar alarm that is activated by opening a window or door.

Planning

1. You can place switches on the windows and doors that are open when the windows and doors are open.

   If a burglar enters by a window or door, will that switch become open or closed?

   This will be part of the input circuit to a relay.

2. Will the input circuit be on or off when a burglar enters?

   - ‘Normally open’ type relay – when the input circuit is off the output circuit is also off.
   - ‘Normally closed’ type relay – when the input circuit is off the output circuit is on.

3. To make a bell or buzzer sound when the burglar enters do you need a ‘normally open’ or ‘normally closed’ type of relay?

4. The diagram below shows how a relay works. Look at it and decide which type of relay it is.
Designing a burglar alarm (continued)

2. Draw the circuit symbol for the type of relay you selected in question 3.

3. Draw the input circuit attached to the coil shown in the relay symbol. Include switches for one door and two windows.
   (Remember to include a power supply!)

4. Draw the output circuit attached to the switch in the relay symbol.
   (Again, remember to include a power supply.)

5. Now check your circuit.

   5. What must be done to stop the alarm sounding?
   6. Suggest another practical use for a relay.
Investigate: How to make an electromagnet stronger

Running the activity

The investigation has pupil sheets at Core and Help levels. Pupils have already seen the effect of adding an iron core so this investigation concentrates on establishing the effect of increasing the current and the number of turns on the coil. Some pupils may wish to do preliminary experimental work to establish the range of values to be used (and suitable values for the fixed variable); the time available will probably dictate whether teachers wish to allow this.

A low-voltage dc power supply and variable resistor (variable power supply) are used to vary the current. These should already be connected by the technician with two output leads marked + and − taped to the bench. Pupils vary the current by means of the slider. You may wish to discuss what is happening with more able pupils.

Core: Pupils have made electromagnets in the previous lesson, so most should be able to design a suitable circuit and decide how to measure the strength of the electromagnets – but some groups may need prompting. Teachers may decide to limit the investigation to one variable or groups could investigate different variables, coming together to discuss results at the end. The plan must be checked by the teacher before pupils work in small groups to carry out their plans.

Help: The Help sheets provide extra support in the form of a structured format for pupils to record on the sheet. Pupils are directed to vary the number of turns on the coil as it is easier to carry out than varying the current.

Other relevant material

Skill sheet 5: Drawing charts and graphs
Skill sheet 6: Interpreting graphs
Skill sheet 20: Writing frame: Planning an investigation
Skill sheet 21: Writing frame: Reporting an investigation

Expected outcomes

Core: Pupils should produce a plan to measure the strength of an electromagnet for various currents or numbers of turns on the coil. They should predict the expected relationship. Pupils will carry out their plan, present their results graphically and find out whether their prediction was correct. They will evaluate their evidence and consider how their procedure could be improved and further evidence collected to support their conclusion.

Help: Pupils should achieve similar outcomes to those using the Core sheets, but greater guidance is provided at each stage of the process.

Pitfalls

When reading pupils’ plans, teachers should check that they intend to control the variables correctly. If varying the number of turns the current must be kept constant. This can be done by using the same length of wire in the circuit throughout, simply coiling it around the iron core a different number of times for each test.

If varying the current the number of turns on the coil must remain the same. A large fixed number of turns will make a stronger electromagnet and make it easier to measure its strength.
Investigate: How to make an electromagnet stronger (continued)

Make sure that the paper clips or iron nails used to test the strength of the electromagnet are not magnetised before beginning the experiment. Pupils should check that they remain unmagnetised after each reading has been made and demagnetise them if necessary.

Safety notes
Pupils need to be shown how to use mains operated power supplies safely.
Pupils need to be aware that the wire gets hot when an electric current passes through it.
Pupils must turn off the power supply when they are not taking readings.
Pins and nails have sharp points.

ICT opportunities
It would be possible to set up a spreadsheet for the results and to produce a computer generated graph.

Answers
Plans should include the following steps:
• The purpose of the investigation: How can you make an electromagnet stronger?
• Possible variables for investigation: Current and number of turns on the coil, and the one selected (if a choice is available).
• A method for measuring the strength of the electromagnet: For example the number of paper clips/pins/nails that can be picked up.
• How the chosen variable will be measured: Use an ammeter to measure current/count the number of turns on the coil.
• How the chosen variable will be altered: Current, include a variable resistor in the circuit, and number of turns on the coil, wind the wire around the core a different number of times.
• A suitable circuit diagram: Examples are shown on the right.
• Equipment list.
• Range of values to be used: For example currents from 0.5 A to 3.0 A; from 20 to 50 turns of wire.
• Safety precautions.
• Prediction.
Pupils should obtain best fit straight lines, possibly starting to level off at higher values of current/number of turns. A straight line through the origin indicates proportionality. Some pupils may be able to relate the shape of their graph to the gradual alignment of the domains in the iron core.
Suggested improvements could include increasing the range and number of results taken, more repeat readings and a better way of measuring the strength of the electromagnet (e.g. using smaller objects to be picked up and finding their mass rather than number, using a forcemeter to measure the force needed to separate the electromagnet from a piece of magnetic material).
Investigate: How to make an electromagnet stronger

You are going to plan and carry out an investigation to find out what makes an electromagnet stronger. You are going to collect some evidence and draw a graph to help you to analyse the data and to evaluate your results.

Equipment

- about 1 metre of plastic coated wire stripped at both ends
- two crocodile clips
- wooden cylinder (to form a coil of wire)
- variable power supply
- ammeter
- connecting leads
- heat-resistant mat
- iron rod
- paper clips or iron nails (to test the strength of the electromagnet)
- access to a demagnetising coil carrying alternating current

Planning

1. What is the aim of your investigation? Write down the question you are trying to answer.
2. List the possible input (independent) variables. Choose one or two to investigate, depending on the time available. (Your teacher will tell you whether to choose one or two variables.)
3. How will you measure the strength of the electromagnet?
4. How will you vary the factor you have decided to investigate?
5. What variables will you keep the same, in order to ensure a fair test? What values will they have? (You may be able to do some preliminary practical work to decide on these values.)
6. Draw a diagram of the circuit you will use.
7. Make a list of all the equipment you will need.
8. What will you do to make your results reliable?
9. How many readings will you take, and over what range?
10. What safety precautions will you take? What is the maximum current you can use?
11. Finish your plan. Make sure you have included everything on Skill sheet 20.
12. Check your plan with your teacher.

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Investigate: How to make an electromagnet stronger (continued)

Predicting

13 Predict how you think your chosen variable will affect the strength of the electromagnet.

14 Use your scientific knowledge of magnetism and electromagnets to explain why you think this will happen.

1. If you plan to draw a graph of your results, what shape do you think the graph will be?

Obtaining evidence

15 Draw up a table to record your results.

16 Carry out your investigation and record your results.

Presenting the results

17 Draw a line graph to represent your results.

Considering the evidence

2. Do you think there is a relationship between the strength of the electromagnet and your chosen variable? If so, what is this relationship?

3. Look again at your prediction. Do your results agree with your prediction or not?

Evaluating

4. Do you have enough evidence to make a firm conclusion?

5. How could you have improved what you did?

6. What additional evidence could you get to support your conclusion?
Investigate: How to make an electromagnet stronger

You are going to write a plan and carry out an investigation to find out what makes an electromagnet stronger.

**Equipment**
- about 1 metre of plastic coated wire stripped at both ends
- two crocodile clips
- wooden cylinder (to form a coil of wire)
- low-voltage dc power supply
- connecting leads
- heat-resistant mat
- iron rod
- paper clips or iron nails (to test the strength of the electromagnet)

**Planning**
1. Working in small groups, discuss each point below. Fill in the gaps as you go.

   A Write down the question you want to answer.

   B You should know that an iron core makes a strong electromagnet. The two input (independent) variables you could change are:
   - the in the wire
   - the number of turns of wire

   C The input variable your group is going to investigate is the number of turns of wire used to make your electromagnet. The outcome (dependent) variable is the strength of the electromagnet you make. We will measure this by counting how many the electromagnet will pick up.

   D We will keep these variables the same to make it a fair test (make a list):

   E We will need the following equipment (make a list using the list above to help you):

   F We will each measurement to make sure our results are reliable.

   G We predict that increasing the number of turns of wire will make a stronger electromagnet.
Investigate: How to make an electromagnet stronger (continued)

2. Think about how you will do your investigation. Draw a diagram to show how you plan to set up your equipment.

3. How many readings do you plan to take?
4. How many times will you repeat your readings?
5. What range of values will you take for your input variable?

6. Now show your plan to your teacher.

Obtaining evidence

7. Carry out the investigation you have planned. If you could not design your own circuit you can use the one shown.
8. Record your results in the table below.

Core material ………………… Current stays the same

<table>
<thead>
<tr>
<th>Number of turns of wire</th>
<th>Number of paper clips/nails picked up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

H  We think this because:

............................................................................................................................................................
............................................................................................................................................................

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Investigate: How to make an electromagnet stronger (continued)

Presenting the results

9 Draw a graph of your results.

Considering the evidence

1. Complete these sentences by choosing from the words below.

   - less  more  stronger  weaker

   - The more turns of wire the ....................... paper clips or nails it picked up.
   - The more turns of wire the ....................... the electromagnet.
   - The iron core makes the electromagnet ....................... .
   - If we had used a bigger current we would have made a ....................... electromagnet.

2. The points on your graph should form a best fit straight line.
   What does this tell you about the link between the number of turns of wire and the strength of the electromagnet?

3. Decide what your group is going to say to the class when you report on your investigation.
### Magnetic fields

**Suggested alternative plenary activities** (5–10 minutes)

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Sharing responses</th>
<th>Group feedback</th>
<th>Word game</th>
<th>Looking ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils review five things about a magnet.</td>
<td>Pupils answer questions about magnets by holding up true/false/unsure cards.</td>
<td>Groups of pupils discuss their responses to question 5 in Activity J1a (Core).</td>
<td>Pupils answer clues to fill in a grid and find a mystery word.</td>
<td>Pupils predict the magnetic field pattern in the space between the poles of two bar magnets.</td>
</tr>
</tbody>
</table>

**Review learning**
- Pupils write down five things about a magnet.
- Working in groups they then agree on the five most important things about a magnet.
- A pupil from each group reports back to the class and a list is made on the board which pupils can copy down.

**Sharing responses**
- Make a set of cards for each pupil, ‘true’, ‘false’ and ‘unsure’ (see the bottom half of the Teacher sheet). You could use a different colour card for each word.
- Read out the statements on the Teacher sheet. Pupils hold up the card for their answer simultaneously.
- Explain the answers. If many pupils get an answer wrong, repeat the statement later.

**Group feedback**
- Pupils discuss their responses to Q5 in Activity J1a (Core).

**Word game**
- Pupils solve six clues based on magnetism.
- Pupils place their answers in a grid to make a mystery word.

**Looking ahead**
- Pupils predict the magnetic field pattern in the space between the poles of two bar magnets placed on the OHP with (i) unlike poles adjacent (ii) like poles adjacent.
- Selected pupils sketch their ideas on the board.
- Finally the teacher sprinkles iron filings over the magnets to reveal the magnetic field.

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This worksheet may have been altered from the original on the CD-ROM.
Sharing responses

Read out the statements below and ask pupils to answer true or false (or unsure) by holding up a card.

1. All metals are magnetic. [False]
2. The north pole of the Earth behaves like a south pole. [True]
3. Two north poles repel. [True]
4. Two south poles attract. [False]
5. A plotting compass always points to the north pole of the Earth. [False]
6. A piece of copper tubing is attracted to a magnet. [False]
7. A magnet picks up aluminium. [False]
8. The tape in a cassette player is magnetic. [True]
9. When a magnet is allowed to move freely, the end which points south is called the south seeking pole. [True]
10. A magnet can attract or repel a steel bar. [False]
11. All magnets have a region of space around them called a magnetic field. [True]
12. The closer together the magnetic field lines, the stronger the magnetic field. [True]
13. Magnetism is a contact force. [False]
14. There is a force on an iron nail placed in a magnetic field. [True]
15. Fridge magnets are only attracted to fridges. [False]

Display the words below in large type for pupils to hold up for you to see. Make them into $2 \times 4 = 8$ cards to a sheet.

True
True
True
True

Display the words below in large type for pupils to hold up for you to see. Make them into $2 \times 4 = 8$ cards to a sheet.

False
False
False
False

Display the words below in large type for pupils to hold up for you to see. Make them into $2 \times 4 = 8$ cards to a sheet.

Unsure
Unsure
Unsure
Unsure

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J1 Magnetic fields

Word game

Fill in the answers to the six clues in the grid below.

When you have finished, the shaded squares should spell out a word connected with this topic.

Clues

1. These materials are attracted to a magnet.
2. Unlike poles do this.
3. A type of pole.
4. This is a magnetic material.
5. A north-seeking pole seeks the north pole of the …
6. Iron is used to make this type of magnet.

Clue Grid:

1

2

3

4

5

6
### Magnets

#### Suggested alternative plenary activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Sharing responses</th>
<th>Group feedback</th>
<th>Word game</th>
<th>Looking ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils answer multiple-choice questions.</td>
<td>Pupils recap magnetic field patterns found in Activity J2a.</td>
<td>Pupils find out what is in a mystery box and each group reports back on its findings.</td>
<td>Pupils play bingo.</td>
<td>Demonstration of picking up a line of steel paper clips/pins and iron nails with a bar magnet.</td>
</tr>
</tbody>
</table>

**Review learning**
- Pupils answer the multiple-choice quiz questions by jotting down the letter for the answer.
- Go through each question and answer with the class, asking for a show of hands for each possible answer so you can see how much pupils know already.

**Sharing responses**
- Pupils recall the magnetic field patterns found in Activity J2a.
- The OHP is used to show these and, if time, other magnetic fields.

**Group feedback**
- Each group is given a sealed matchbox, with a small magnet embedded in it, and a plotting compass. Their task is to find out what is in the box, how it is arranged and where its poles are located within a time limit of 5 minutes.
- A pupil from each group reports back to the class followed by a show of hands to see how many groups were correct.

**Word game**
- Pupils select nine words from the list to write into their bingo grid.
- Read out definitions from the teacher sheet in any order. Pupils match these to their chosen words. The game is over when a pupil can strike out a line.
- The 'winning' pupil has to recall the definitions of the words as they read each one in the winning line to the class.

**Looking ahead**
- Pupils watch as you pick up a line of steel paper clips (or pins) with a bar magnet.
- Repeat this using iron nails.
- Pupils compare the effect of removing the magnet carefully in each case.

**Note**: This can be done by the pupils if time and resources allow.

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➔ Pupil sheet
Answers 1b; 2a; 3b; 4c

➔ Technician sheet

➔ Pupil sheet

➔ Technician sheet

Answers
- A small bar magnet is placed diagonally across the box. The technician will know its orientation and the position of N and S poles.

➔ Pupil sheet

➔ Teacher sheet

➔ Technician sheet

Expected result: the iron nails lose their magnetism when the magnet is removed but the steel paper clips or pins remain magnetised and so stay attracted to each other in a line.
Magnets

Review learning

1. Which of these materials is magnetic?
   a. brass
   b. iron
   c. zinc

2. In which direction would the north pole of a compass point at the north pole?
   a. downwards
   b. upwards
   c. horizontally

3. The Earth has a magnetic field that looks as if there is a huge bar magnet buried inside. Which of these statements is correct?
   a. The N pole of the magnet is pointing towards the N pole of the Earth.
   b. The N pole of the magnet is pointing towards the S pole of the Earth.
   c. The N and S poles of the magnet lie on a plane going through the equator.

4. Which of the following tests would tell you if an object is a magnet?
   a. See if it attracts some steel pins.
   b. See if it attracts another magnet.
   c. See if it repels another magnet.
Group feedback

1. With the matchbox some distance away, use the plotting compass to mark the direction of the Earth's magnetic field at the top of this sheet of paper.

2. Place the matchbox provided in the centre of the space below on this sheet of paper. Draw round the matchbox.

3. Use the plotting compass to plot the magnetic field around the matchbox.

4. Decide what you think is hidden in the matchbox and the position of any N or S poles.
Word game

Bingo!

Choose nine words from the list below and write them in the empty grid.

- attract
- compass
- iron
- magnetic
- magnetic field
- magnetise
- nickel
- north
- pole
- repel
- south
- steel

Cross out each word when you hear the teacher read out its definition.

Shout BINGO! when you have crossed out a line of three words on the card.

The line can be across, down or diagonally.
Word game

Teacher sheet
Read out the definitions below, in any order.

1. What two opposite magnetic poles do. [Attract]
2. A magnetic object used for navigation. [Compass]
3. A common metal that makes a temporary magnet. [Iron]
4. A type of material capable of being made into a magnet. [Magnetic]
5. The space around a magnet where magnetic forces can be detected. [Magnetic field]
6. To make into a magnet. [Magnetise]
7. A hard silvery magnetic material. [Nickel]
8. The end of a magnet that points to the Earth’s north pole. [North]
9. A place where the lines of force of a magnetic field enter or leave the magnet. [Pole]
10. What the south poles of two magnets do. [Repel]
11. The end of a magnet that points to the Earth’s south pole. [South]
12. This material makes a permanent magnet. [Steel]
Magnets

Sharing responses

Technician sheet
Please put out the following for a demonstration on magnetic fields:
- two bar magnets
- OHP
- iron filings
- acetate sheet (to prevent iron filings touching the magnets)

Group feedback

Technician sheet
Please make the following – one per group:
A small bar magnet embedded in a matchbox. It should be packed around with soft paper, sand or similar so that the magnet cannot be felt. The matchbox should then be taped so that it cannot be opened.
Each group will also require a plotting compass.

Note: The teacher will need to know the position of the magnet and the location of the N and S poles.

Looking ahead

Technician sheet
Please put out the following for a demonstration (or group practical activity):
- two bar magnets
- steel paper clips or pins
- iron nails
### Suggested alternative plenary activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Review learning</th>
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<th>Group feedback</th>
<th>Word game</th>
<th>Looking ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working in pairs, pupils prepare four questions for their partner to answer.</td>
<td>Pupils all stand up and sit down when they have defined a word correctly.</td>
<td>Group discussion of results of Activity J3a or J3b.</td>
<td>Check progress - Pupils fill in the gaps in a passage summarising the unit so far.</td>
<td>Demonstration of the electrical method of making a magnet.</td>
</tr>
</tbody>
</table>

#### Review learning
- Quick quiz - ‘What?’, ‘When?’, ‘Why?’, ‘How?’
- Working in pairs, pupils prepare four questions on today’s lesson for their partner to answer.
- If time permits, questions can be exchanged with other groups.

#### Sharing responses
- Ask pupils to stand. Ask each, in turn, to explain the meaning of a word (see opposite).
- Pupils who give a correct explanation can sit down.
- Differentiate the words so that all pupils sit down after the second or third attempt. This can also be achieved by using some words more than once.

#### Group feedback
- Pupils discuss the results of Activity J3a or J3b, working in small groups.
- A representative of each group reports to class.

#### Word game/Check progress
- Pupils fill in the gaps in a passage summarising the unit so far.

#### Looking ahead
- Pupils take part in a class discussion on the problems of making a magnet by the stroking method.
- Show how a long nail (or similar) can be made into a magnet by winding a coil of wire around it.

---

**Words**
magnet, attract, repel, magnetic material, magnetic field, permanent magnet, temporary magnet, north pole, south pole, compass, navigate, stroking method, induced magnetism, Earth’s magnetic field, magnetised

**Equipment**
long iron nail (or similar), length of insulated wire wound around nail with turns touching and covering most of its length and with a minimum of 10 cm free at either end, two crocodile clips (to attach to ends of insulated wire), two connecting leads, low-voltage high-current power supply (e.g. Westminster type), small pins, paper clips or nails (to show that the nail is magnetised)

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Making magnets

Word game

Iron, steel, cobalt, ___________________ and iron ___________________ are called magnetic materials.

Like poles of a magnet _______________; unlike poles _______________.

If a N pole is used in the stroking method of magnetisation, the end where the stroking begins is a _______________ pole.

If the N pole of a magnet is brought near to an unmagnetised iron nail, then the nail becomes _______________. The end of the nail nearest the N pole of the magnet becomes a _______________ pole.

When the magnet is removed the iron nail loses its magnetism because iron can only be a _______________ magnet. Steel and iron oxide can be used to make a _______________ magnet.

An area where magnets _______________ or _______________ is called a magnetic field.

The Earth’s magnetic field is like that of a _______________ magnet with its _______________ pole in the northern hemisphere.

The only test for a magnet is _______________ with another magnet.
J4 Electromagnets

**Suggested alternative plenary activities (5–10 minutes)**

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Sharing responses</th>
<th>Word game (1)</th>
<th>Word game (2)</th>
<th>Looking back</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop game revising the work done so far in this lesson.</td>
<td>Whole class discussion of the results of Activity J4a or J4b.</td>
<td>Demonstration of a relay. Pupils write a series of statements in the correct order to explain how a relay works.</td>
<td>Wordsearch to familiarise pupils with the terminology used in this unit.</td>
<td>Pupils revise and consolidate knowledge from the unit.</td>
</tr>
</tbody>
</table>

**Review learning**

Pupils play a loop game revising the work done so far in this lesson.

- Give each pupil a card containing a question and an answer.
- Ask one pupil to stand up and read out the question on their card. The pupil then sits down.
- The pupil who has an appropriate answer to this question stands up and reads out their answer. The pupil then asks the question on their card and sits down, and so on.
- The game is complete when the pupil who started the game stands up for a second time to read out the answer on their card. The loop is complete.
- If there are not enough question/answer cards for the whole class, you may need to make extra copies. Some pupils will have the same question/answer card – the first one to stand up gets to read their answer and ask their question.
- Before cutting up the pupil sheet, copy and reorder it so that you hold a copy of the correct answers next to their respective questions.

**Sharing responses**

- Pupils take part in a whole class discussion of the results of Activity J4a or J4b.

**Word game (1)**

- Pupils watch a demonstration of a relay with an explanation of how it works. (See pupil sheet for the diagram of equipment needed.)
- Pupils write a series of statements in the correct order to explain how the relay works.

**Word game (2)**

- Pupils complete a wordsearch to provide practice in learning the terminology used in this unit.
- Ring the words on a copy of the pupil sheet and show it as an OHT for them to check their answers.

**Looking back**

- Pupils revise and consolidate knowledge from the unit.
- They can use the Unit map, Pupil check list, or the Test yourself questions.
### Electromagnets

#### Review learning

<table>
<thead>
<tr>
<th>Q</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q</strong> An electromagnet has two of these.</td>
<td><strong>A</strong> move cars around in a scrap yard</td>
</tr>
<tr>
<td><strong>Q</strong> When an electromagnet is magnetised it will do this.</td>
<td><strong>A</strong> poles</td>
</tr>
<tr>
<td><strong>Q</strong> Complete the sentence. The magnetic field due to a coil of wire is similar to the magnetic field due to a</td>
<td><strong>A</strong> attract some steel pins</td>
</tr>
<tr>
<td><strong>Q</strong> This can be used to make a magnet.</td>
<td><strong>A</strong> bar magnet</td>
</tr>
<tr>
<td><strong>Q</strong> This piece of equipment contains an electromagnet.</td>
<td><strong>A</strong> electric current</td>
</tr>
<tr>
<td><strong>Q</strong> Magnetic field lines inside the coils of an electromagnet always go in this direction.</td>
<td><strong>A</strong> electric bell</td>
</tr>
<tr>
<td><strong>Q</strong> A relay, containing an electromagnet, is used for this.</td>
<td><strong>A</strong> from south to north</td>
</tr>
</tbody>
</table>

| **Q** If an electromagnet had a steel core, what would happen when the current was switched off? | **A** to switch on the starter motor of a car |
| **Q** Which of these materials, if placed inside a solenoid, would not become magnetised when the current is switched on? copper iron nickel steel | **A** the steel core would remain magnetised |
| **Q** What shape is the magnetic field due to a current in a long straight wire? | **A** copper |
| **Q** Why do electromagnets have an iron core? | **A** circular / cylindrical |
| **Q** Magnetic field lines around the outside of an electromagnet always go in this direction. | **A** to switch the magnetism on and off |
| **Q** An electromagnet can be used to do this. | **A** from north to south |

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This worksheet may have been altered from the original on the CD-ROM.
Your teacher will demonstrate how an electromagnetic relay works. Look at the diagram of the relay below being used to switch on a lamp.

Read through the following sentences and put them in the correct order to explain how a relay works:

A The lamp circuit is completed.
B The armature is attracted to the iron core.
C When the switch is closed a current passes through the solenoid.
D The lamp is lit.
E The contacts close.
F This magnetises the iron core.
J4 Electromagnets

Word game (2)

All these words are connected with magnetic fields. See how many of them you can find in the wordsearch.

attract filings repel coil iron
seeking current magnet solenoid electric
north south field pole stroking

M A X B A H F I L I N G S
S N O R T H I P C O F A O
T W P U T M S I O G M G L
N I O D R H R K V L T N E
T S R F A T E T L E E I N
E A D I C O I L E B U K O
N U F E T N J S P N T O I
G C L L H F O S E Y V R D
A E E D E C U R R E N T A
M G N I K E E S I K F S T
**Variables - Think about**

**Suggested alternative plenary activities (5-10 minutes)**

<table>
<thead>
<tr>
<th>Group feedback</th>
<th>Bridging to other topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils discuss what is meant by a key variable and the different methods of measuring dependent/outcome variables.</td>
<td>The importance of controlling variables in an investigation.</td>
</tr>
</tbody>
</table>

**Group feedback**

- Pupils use the activity they have done in the Pupil book to decide what is meant by a key variable. The teacher should ensure that they all know that it is an input/independent variable that has a large effect on the dependent/outcome variable.

- Pupils discuss the different methods used to measure the dependent/outcome variable in J5 of the Pupil book.

**Bridging to other topics**

- Pupils discuss why it is important to control variables in investigative work if sensible conclusions are to be made. This could be likened to the need for selecting a representative sample of the population (controlling the variables) when carrying out public opinion surveys, if the results are to be an accurate representation of the views of the general public (a fair test).

- Pupils link this to the way in which they have controlled variables in previous investigative work.
Investigate: How to make an electromagnet stronger

Review learning
- Pupils discuss, with the teacher's guidance, the planning procedure.
- Pupils discuss what the data collected can be used to suggest.

Group feedback
Pupils work in groups to discuss:
- how they controlled the variables
- how they measured the strength of the electromagnet
- the results for different variables
Each group then reports to the class.

Analysing
- Pupils take part in a teacher-led analysis of the investigation.
- Pupils discuss whether their results match their predictions, how strong the correlation is, and if there is enough evidence to support their conclusions.

Evaluating
- Pupils take part in a teacher-led evaluation of:
  - whether the investigation was a fair test
  - the problems of getting good results
  - the need to repeat values to ensure reliability
  - possible improvements to the method.
1 Look at this collection of materials.

- iron nails
- copper pipe
- aluminium drinks can
- piece of cobalt
- gold ring
- piece of nickel
- piece of paper
- plastic ruler
- drinking glass

Draw a circle around the magnetic materials.

2 Underline the right words. Cross out the wrong words.

a Magnets have two ends called the north / west pole and the east / south pole.

b Magnetic materials stick to / fall off magnets.

c Like poles attract / repel, which means they pull / push apart.

d Opposite poles attract / repel, which means they pull / push together.

e Around a magnet there is a magnetic room / field / wood.

f To see the magnetic field I could use copper / iron / plastic filings.

g The closer I am to the magnet, the weaker / stronger the magnetic field and the magnetic field lines are further apart from / closer to each other.
3 Look at this drawing of a bar magnet. It shows half of the magnetic field around it.

a Complete the other half of the magnetic field around the bar magnet.

b Where are the magnetic field lines the closest?

- close to the poles / far away from the poles / far away from the magnet / close to the magnet

c Where is the magnetic field the strongest?

- close to the poles / far away from the poles / far away from the magnet / close to the magnet

4 Look at these pairs of magnets.

Circle the pairs of magnets that will attract each other.
1 Write true or false for each sentence.

a The Earth is like a huge horseshoe magnet. .................

b The north pole of a compass needle points to the Earth’s South Pole. .................

c The arrowhead of a compass needle always points north. .................

d You can use a compass to find out the direction of the magnetic field lines around a magnet. .................

e The magnetic field lines run from the north pole of a magnet to its south pole. .................

2 Look at this drawing of the magnetic field around a bar magnet.

Add arrows to show the direction of the magnetic field lines.
3 Look at these drawings of magnetic fields. Some of them are wrong.

- **A**
  - [ ]
  - [ ]
  - [ ]
  - [ ]

- **B**
  - [ ]
  - [ ]
  - [ ]
  - [ ]

- **C**
  - [ ]
  - [ ]
  - [ ]
  - [ ]

- **D**
  - [ ]
  - [ ]
  - [ ]
  - [ ]

- **E**
  - [ ]
  - [ ]
  - [ ]
  - [ ]

- **F**
  - [ ]
  - [ ]
  - [ ]
  - [ ]

**a** Tick (✓) the drawings that are correct.

**b** Cross (✗) the drawings that are wrong. Circle the parts of the drawings that are wrong.

4 Tick the correct answers.

- **a** Sailors use compasses to help them navigate. ‘Navigate’ means to …
  - [ ] travel by ship
  - [ ] find your way around
  - [ ] use a compass

- **b** Before compasses, sailors found their way using …
  - [ ] the Sun and the stars
  - [ ] the winds
  - [ ] the waves
1. Draw lines to match the materials to their descriptions.

- **lodestone**: Makes a strong permanent magnet.
- **iron oxide**: Makes a weak permanent magnet.
- **steel**: A natural magnet.
- **iron**: Only makes a temporary magnet.

2. You can turn a steel needle into a magnet. Tick the sentence that describes how you can do this.

- Stroke the steel needle first with the north pole of a magnet, then with the south pole.
- Stroke up and down the steel needle with just one pole of the magnet.
- Stroke the steel needle with one pole of the magnet once.
- Stroke the steel needle many times with one pole of the magnet, always moving in the same direction.
3 Fill the gaps in the sentences below. Use the word 'magnets' or the words 'magnetic materials'.

a Two ____________________________ will attract and repel each other.

b Two ____________________________ will not attract or repel each other.

c ____________________________ are only attracted to ____________________________ , they are never repelled.

4 Some different materials were tested with a strong permanent magnet. Each material was touched first with the north pole, then with the south pole. Here's what happened.

<table>
<thead>
<tr>
<th>Material</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test with N pole</td>
<td>attracted</td>
<td>attracted</td>
<td>attracted</td>
<td>repelled</td>
</tr>
<tr>
<td>Test with S pole</td>
<td>attracted</td>
<td>repelled</td>
<td>attracted</td>
<td>attracted</td>
</tr>
</tbody>
</table>

a Which materials are magnetic materials? ____________________________

b Which materials are magnets? ____________________________
1 Use some of these words to fill in the gaps.

a Magnets made using electricity are called ________________.

b Electromagnets are useful because they can be switched ________________.

c The ________________ around an electromagnet is just like the one around a bar magnet.

d An electromagnet can pick up three metals: ________________

________________________ and ________________.
2 Look at this diagram of an electromagnet.

- Use these words to label the diagram.
  - coil
  - switch
  - core
  - power supply

- How many turns are there in the coil? ________________

3 Look at this list of changes you could make to an electromagnet.

- use a wooden core
- use more turns in the coil
- use a bigger current
- use fewer turns in the coil
- use a smaller current
- use an iron core

Which changes would make the electromagnet stronger? Colour them red.
1 Jennifer did an experiment on an electromagnet. She wanted to find out if the material the core was made of affected how strong the electromagnet is.

She changed the core and measured how many paperclips the electromagnet could pick up. Here are her results.

<table>
<thead>
<tr>
<th>Core made from</th>
<th>aluminium</th>
<th>glass</th>
<th>nickel</th>
<th>iron</th>
<th>copper</th>
<th>steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paperclips picked up</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>12</td>
<td>0</td>
<td>18</td>
</tr>
</tbody>
</table>

a Look at this list of variables.

- The cores were all the same size and shape.
- The number of turns in the coil was changed each time.
- The current was kept the same.
- The cores were all different shapes and sizes.
- The number of turns in the coil was the same each time.

Find the things on this list that would make the experiment a fair test. Colour them in red.

b Show Jennifer’s results as a bar graph on the graph paper.

c Which cores make the electromagnet stronger?

d Which core makes the strongest electromagnet?
Priti also did an experiment on an electromagnet. She wanted to see how the number of turns in the coil affects the strength of the electromagnet. Here are her results.

<table>
<thead>
<tr>
<th>Number of turns</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paperclips picked up</td>
<td>5</td>
<td>11</td>
<td>22</td>
<td>39</td>
<td>60</td>
</tr>
</tbody>
</table>

a Plot Priti’s results as a line graph on the graph paper below.

b Join up the points with a smooth curve.

c Choose the correct ending for the sentences.

i The more turns in the coil ...

... the more paperclips it picks up

... the fewer paperclips it picks up.

ii The more turns in the coil ...

... the weaker the electromagnet

... the stronger the electromagnet.
**J1 Magnetic fields**

1. Circled – iron nails, piece of cobalt, piece of nickel
2. a. north, south
   b. stick to
   c. repel, push
   d. attract, pull
   e. field
   f. iron
   g. stronger, closer to

3. a. Close to the poles.
   b. Close to the poles.
   c. Close to the poles.


**J2 Magnets**

1. a. false
   b. false
   c. true
   d. true
   e. true

2. The arrows point from the north pole towards the south pole.

3. a. Ticked – A, E
   b. Crossed – B, C, D, F

4. a. Find your way around.
   b. The Sun and the stars.

**J3 Making magnets**

1. lodestone – A natural magnet.
   iron oxide – Makes a strong permanent magnet.
   steel – Makes a weak permanent magnet.
   iron – Only makes a temporary magnet.

2. Tick – Stroke the steel needle many times with one pole of the magnet, always moving in the same direction.

3. a. magnets
   b. Magnetic materials.
   c. magnetic materials, magnets

4. a. A, C
   b. B, D

**J4 Electromagnets**

1. a. electromagnets
   b. On and off.
   c. Magnetic field.
   d. iron, steel, nickel

2. a. Clockwise from top left – switch, power supply, coil, core
   b. 13

3. Coloured red – Use more turns in the coil. Use a bigger current. Use an iron core.

**J5 Variables**

1. a. Coloured red – The cores were all the same size and shape. The current was kept the same. The number of turns in the coil was the same each time.

2. a. A, B
   b. C, D

   c. nickel, iron, and steel
   d. steel

3. a. The more paper clips it picks up.
   b. The stronger the electromagnet.
1a Which of the following will be attracted to a magnet?

- wooden spoon
- crushed car
- copper bracelet
- iron nail
- aluminium saucepan

b What makes magnets push and pull against each other?

c The two sentences below are wrong. Write them correctly. Do not change the underlined sections.
1. Magnets repel each other when a north pole pushes against a south pole.
2. Similar poles on two different magnets will always attract each other.

d Steel is a magnetic material. What substance in steel makes it magnetic?

2a The diagram shows the ends of a large horseshoe magnet.

Describe what will happen to each of the following objects if placed at point X:

i a magnetic needle
ii an aluminium rod.

b What exists between the two poles of the magnet around the area marked X?

c Plastic letters can be bought that stick onto fridges. Explain why they stick onto the fridge door.

d On a bar magnet, where is the magnetism strongest?

e James is using his magnet to attract objects. Here are his results:

Steel screw – not attracted.
Nickel earring – attracted.
Aluminium can – not attracted.
Iron hinge – attracted.

i Which of his observations are correct and which are not?
ii James tried a rusty screw. It was attracted to the magnet. Explain why it was attracted.
iii James used the magnet to investigate some magnetic fields using iron filings. He put the magnet inside a plastic bag. Why was this a good idea?
**EXTENSION**

3. The diagrams show pairs of magnets put close together. Lines of force are shown.

![Diagrams X, Y, and Z showing magnetic fields.]

**a i** In diagram X, what must be true about poles A and B?
   
**ii** Which letter, M (on diagram X) or P (on diagram Y), shows the position of the strongest magnetic field?

**b i** In diagram Y, what must be true about poles C and D?

**ii** What must be true about the strength of the magnetic field at point P?

**c i** In diagram Z, write down the **type** of pole there would be at poles R, S, T and U.

**ii** Where would the magnetic field be at its strongest?

**iii** What feature, about the space taken up by magnetic fields, cannot be seen from the diagrams?

**d** In diagram Y, a steel ball bearing is placed at point P, exactly in the centre between the two magnetic poles.

**i** What will happen to the ball bearing?

**ii** What will happen to the ball bearing if the right hand magnet is carefully but very quickly removed?
HELP

1 a Copy and complete the following sentences:
   i. Before they had a compass, sailors used to find their way using ________________.
   ii. Using a compass is better than the old ways because ________________.
   iii. The pointed end of a compass needle always points to the south end of a bar magnet because ________________.

   b. Near a magnet, the compass does not point the usual way. Write a sentence to explain why not.

   c. Sam the sailor has an unmagnetised nail hanging on a piece of string in his boat. Why won’t it help him find his way in bad weather?

CORE

2. Look at this diagram of some small compasses close to a bar magnet.

   a. Which compass needles would not point in the directions shown?

   b. For those that are pointing correctly, what are they showing?

   c. If the bar magnet was removed, what would happen to the compasses that are pointing correctly?

3. Cheryl is out for a walk and is not sure of her direction. She looks at the watch on her right wrist to see what the time is. It has a shiny steel case. She decides to use her compass to make sure that she gets home in time for tea.

   a. Why should Cheryl hold the compass in her left hand?

   b. Explain how and why the compass will help Cheryl to know which way to walk, if her house is to the south.
EXTENSION

4 Geoff is a geologist. He enjoys exploring in the mountains, finding out about the rocks and minerals exposed at the surface. Geoff is also a keen mountaineer and his compass has got him out of trouble on more than one occasion.

Last summer, Geoff went to the Isle of Skye in Scotland. One day, while collecting rocks up on the Cuillin Mountains, Geoff discovered that his compass did not seem to be pointing to the north. He thought this was odd, as it had been fine earlier in the day. Fortunately, it was a clear day and he found his way to the path leading down to his campsite. Thick clouds rolled in from the sea but, luckily, Geoff's compass now seemed to be working properly again, so he did not get lost.

When he examined the rocks he had collected he found that some of them contained a lot of iron oxide.

a Suggest a reason why Geoff's compass started to give false directions.

b Suggest why, later in the same day, the compass began to work properly again.

c i Describe how the magnetic field around the Earth is similar to the field around Geoff's compass needle.

ii In what way is the field around the compass needle different to that around the Earth?

iii Explain why there is this difference between the two fields.

5 Some people who have a problem with their heart have a special device in their chest to make an irregular heartbeat regular. This device is called a pacemaker. Very strong magnetic fields can make someone's pacemaker stop working.

Ramana works in a laboratory. She operates a machine called a mass spectrometer, which contains a very powerful magnet. The person who runs the laboratory had a pacemaker fitted three years ago.

a What could be done to make sure that the pacemaker is not affected by the very strong magnetic field from the mass spectrometer?

b Explain why your suggestion would be effective.
Making magnets

HELP

1. Look at the information about magnetic material in this table.

<table>
<thead>
<tr>
<th>Magnet</th>
<th>How did it become magnetic?</th>
<th>Does it stay magnetic?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Needed a strong magnet to make it</td>
<td>Stays magnetic</td>
</tr>
<tr>
<td>B</td>
<td>Already magnetic</td>
<td>Stays magnetic</td>
</tr>
<tr>
<td>C</td>
<td>Needed a strong magnet to make it</td>
<td>Loses its magnetism</td>
</tr>
<tr>
<td>D</td>
<td>Needed a strong magnet to make it</td>
<td>Stays weakly magnetic</td>
</tr>
</tbody>
</table>

Write the letters for each magnet as a list. Next to each letter say which substance you think it is made of. Choose from:

- lodestone
- iron
- steel
- iron oxide

2. a. You are explaining to a friend how to make a magnet from a steel nail. Write one or two sentences telling him or her what to do.

b. Will the magnet be permanent or temporary?

c. Explain how you know this.

CORE

3. a. Write two or three sentences to explain how you can test a substance to find out whether it is a magnet, or just made from a magnetic material.

b. Look at the diagrams below. They each show a needle, floating on some cork in a bowl of water, looking from above.

   - North
   - South

   i. Which needle or needles is/are magnets?
   ii. Explain how you reached your answer.
   iii. What would happen to needle A if you swung a permanent magnet, in clockwise circles, 10cm above the needle? Assume that the needle does not jump up and stick onto the magnet.
   iv. Needle B does not move when a magnet is brought up close to it. What does this tell you about this needle?
EXTENSION

4 Use a particle model to explain each of the observations below.
   a Steel can be magnetised but copper cannot.
   b Each of the following things can destroy the magnetism in a weak permanent magnet:
      i Dropping it onto a hard floor.
      ii Keeping it on a shelf next to a very strong permanent magnet.
      iii Stroking it with the north pole of a magnet, from south to north.

5 Draw simple diagrams to show the particles in:
   a a strong permanent magnet
   b a magnetic material that is not a permanent magnet and is not attached to one.
HELP

1 Copy the boxes shown below, then draw lines between them to make correct statements.

- A steel core makes an electromagnet stronger.
- Adding more coils of wire is like the one found around a bar magnet.
- An electromagnet’s magnetic field the stronger the field of the electromagnet.
- A smaller current through coils makes an electromagnet permanent.
- The more paper clips attracted makes an electromagnet weaker.

CORE

2 You will need graph paper for this question.

Danny made and tested an electromagnet. The data in the table shows the number of paper clips lifted by his electromagnet.

<table>
<thead>
<tr>
<th>Current (A)</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of clips lifted</td>
<td>12</td>
<td>19</td>
<td>29</td>
<td>32</td>
<td>60</td>
<td>0</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

a Plot the data as a line graph.

b Use the graph to find out the number of paper clips that can be lifted with a current of 2.5A. You must show, on the graph, how you obtained your answer.

c What do we call a result like the one at 3.5A?

d Other than increasing the current even more, what could Danny do to make his electromagnet stronger still?
EXTENSION

3  a  Using ideas about particles, explain why an electromagnet with a steel core remains magnetic, even when the current is switched off, but one with an iron core loses its magnetism.

b  Look at the diagrams of two wires, both carrying the same amount of electric current. The arrows show the direction of the current and, in diagram A, the magnetic field lines.

i  In diagram A, which of the compass needles is pointing in the correct direction?

ii  If the current in the wire shown in diagram A was flowing the opposite way, what would happen to the needle of the compass you chose in question b i?

iii  Which of the two arrangements shown would have the most powerful magnetic field? Explain your choice.

4  You will need to think about electrical circuits, as well as magnetism, for this question. Look at this diagram of an electric doorbell.

a  Explain why, when the doorbell (the switch) is pressed, the striker hits the gong. Give full details about both current and magnetism.

b  Explain why, as soon as the striker hits the gong, it flies back to its original position.

c  i  From what material must the core of the electromagnet be constructed?

ii  Explain why this material must be used.

d  What must be true about the material from which the armature has been made?
## Magnetic fields

### HELP

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Crushed car. Iron nail.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Deduct one mark for each incorrect item mentioned.</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>Magnetic force</td>
<td>1</td>
</tr>
<tr>
<td>c i</td>
<td>Magnets repel each other when a north pole pushes against a north pole (or two south poles). Underscore shows the pupil's answer.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>Different/opposite poles on two different magnets will always attract each other. Underscore shows the pupil's answer.</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>Iron</td>
<td>1</td>
</tr>
</tbody>
</table>

Total for Help 6

### CORE

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a i</td>
<td>Needle spins/turns/moves to point towards the poles.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>Nothing happens/no change/it stays in the same place.</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>The magnetic field.</td>
<td>1</td>
</tr>
<tr>
<td>c</td>
<td>They contain a magnet that is attracted to the steel door.</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>At the ends/poles.</td>
<td>1</td>
</tr>
<tr>
<td>e i</td>
<td>Steel screw is incorrect. Nickel earring is correct.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Aluminium can is correct. Iron hinge is correct.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>Rust is iron oxide which is magnetic.</td>
<td>1</td>
</tr>
<tr>
<td>iii</td>
<td>Stops the iron filings sticking permanently to the magnet. Accept equivalent answers.</td>
<td>1</td>
</tr>
</tbody>
</table>

Total for Core 14

### EXTENSION

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 a i</td>
<td>They must be opposite.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>M</td>
<td>1</td>
</tr>
<tr>
<td>b i</td>
<td>They must be the same.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>There is no magnetic field/it is very weak.</td>
<td>1</td>
</tr>
<tr>
<td>c i</td>
<td>Accept any combination that makes R and T and S and U opposite.</td>
<td>2</td>
</tr>
<tr>
<td>ii</td>
<td>Between the ends of the magnets.</td>
<td>1</td>
</tr>
<tr>
<td>iii</td>
<td>It is three-dimensional.</td>
<td>1</td>
</tr>
<tr>
<td>d i</td>
<td>Nothing/it stays in the same place/it does not move.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>It will roll to the left-hand magnet.</td>
<td>1</td>
</tr>
</tbody>
</table>

Total for Extension 10
**MAGNETS**

**HELP**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a i</td>
<td>Before they had a compass sailors used to find their way using the Sun and the stars. Underline shows the pupil's answer.</td>
<td>1</td>
</tr>
<tr>
<td>1 a ii</td>
<td>Using a compass is better than the old ways because it works when the weather is bad/when you cannot see the sky/if it is cloudy. Underline shows the pupil's answer.</td>
<td>1</td>
</tr>
<tr>
<td>1 a iii</td>
<td>The pointed end of a compass needle always points to the south end of a bar magnet because the pointed end is a north pole/the opposite pole. Underline shows the pupil's answer.</td>
<td>1</td>
</tr>
<tr>
<td>1 b</td>
<td>The compass needle is attracted to/affected by the magnet.</td>
<td>1</td>
</tr>
<tr>
<td>1 c</td>
<td>Unmagnetised iron is not attracted by the Earth's magnetic field.</td>
<td>1</td>
</tr>
</tbody>
</table>

Total for Help 5

**CORE**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 a</td>
<td>B and C.</td>
<td>2</td>
</tr>
<tr>
<td>2 b</td>
<td>The magnetic field of the bar magnet.</td>
<td>1</td>
</tr>
<tr>
<td>2 c</td>
<td>They would point north-south. Accept equivalent answers.</td>
<td>1</td>
</tr>
<tr>
<td>3 a</td>
<td>So that it is not affected by/attracted to the iron watch on her right.</td>
<td>1</td>
</tr>
<tr>
<td>3 b</td>
<td>Compass needle lines up in the Earth's magnetic field. The arrow points towards the Earth's north pole. So Cheryl can see which way is south. Accept equivalent responses.</td>
<td>1</td>
</tr>
</tbody>
</table>

Total for Core 8

**EXTENSION**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 a</td>
<td>Iron oxide (in the rocks) is magnetic and affected the compass needle.</td>
<td>1</td>
</tr>
<tr>
<td>4 b</td>
<td>Not all of the rocks were magnetic/contained iron oxide.</td>
<td>1</td>
</tr>
<tr>
<td>4 c i</td>
<td>Concentrated at the poles. Curves from one pole to the other.</td>
<td>1</td>
</tr>
<tr>
<td>4 c ii</td>
<td>The field lines run in opposite directions.</td>
<td>1</td>
</tr>
<tr>
<td>4 c iii</td>
<td>The north pole of the earth is really a south pole so the earth's magnet is the opposite way round to the compass needle.</td>
<td>1</td>
</tr>
<tr>
<td>5 a</td>
<td>Line the room with nickel/cobalt/iron/a magnetic material.</td>
<td>1</td>
</tr>
<tr>
<td>5 b</td>
<td>The lining will act as a magnetic shield and prevent the strong magnetic field from getting outside the room.</td>
<td>1</td>
</tr>
</tbody>
</table>

Total for Extension 11

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HELP

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A – iron oxide</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>B – lodestone</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>C – (pure) iron</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>D – steel</td>
<td>1</td>
</tr>
<tr>
<td>2 a</td>
<td>Get a strong permanent magnet.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Stroke the substance with the magnet.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Always in the same direction.</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Permanent</td>
<td>1</td>
</tr>
<tr>
<td>c</td>
<td>Steel makes permanent magnets/it is made from steel.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total for Help</strong></td>
<td><strong>9</strong></td>
</tr>
</tbody>
</table>

CORE

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 a</td>
<td>Bring both poles of a magnet up to the substance.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>If both poles attract it, it is a magnetic substance.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>If one pole repels it, it is a magnet.</td>
<td>1</td>
</tr>
<tr>
<td>b i</td>
<td>A and C.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ii Only ones pointing north–south.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>iii It would spin clockwise.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>iv It is not made from a magnetic material.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total for Core</strong></td>
<td><strong>8</strong></td>
</tr>
</tbody>
</table>

EXTENSION

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 a</td>
<td>Particles in steel are tiny magnets.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>They can line up with their north poles all pointing in the same direction.</td>
<td>1</td>
</tr>
<tr>
<td>b i</td>
<td>The particles are shaken out of their north-south orientation.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ii The strong magnetic field can pull some of the particles out of their north-south orientation.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>iii Particles are pulled the other way round but not all at once.</td>
<td>1</td>
</tr>
<tr>
<td>5 a</td>
<td>Diagram shows particles pointing along the long axis poles clearly all the same way round.</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Diagram shows particles with poles in a random arrangement.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total for Extension</strong></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>
# Electromagnets

## HELP

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
</table>
| 1        | Links should be:  
Left 1 to right 4.  
Left 2 to right 1.  
Left 3 to right 2.  
Left 4 to right 5.  
Left 5 to right 3. | 1    |

Total for Help 5

## CORE

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
</table>
| 2a       | Sensible scales.  
Labelled axes.  
Accurate plots. (Deduct 1 mark for each error to a maximum of 2.)  
Straight line.  
Line goes through origin. | 1    |
| b        | 50 (accept 49 or 51)  
Working out shown on graph. | 1    |
| c        | An anomalous result. | 1    |
| d        | Add more coils. | 1    |

Total for Core 10

## EXTENSION

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
</table>
| 3a       | Steel core particles stay lined up when current is off.  
Iron particles become randomly orientated when current is off. | 1    |
| b i      | Needle X. | 1    |
| ii       | It would point in the opposite direction/swing round 180 degrees. | 1    |
| iii      | Arrangement B  
because the core and the coil both have a magnetic field  
which add together when the current is on. | 1    |

Total for Extension 19
Magnets and electromagnets

1. a Name the four metals that a magnet will pick up.
   1 ____________  2 ____________  3 ____________  4 ____________
   
   b Name two metals that a magnet will not pick up.
   1 ____________  2 ____________

2. a Where is the magnetism strongest on a magnet? Underline the correct answer.
   at the top    at the ends    in the middle    underneath
   
   b What is the name for the part of the magnet you have underlined?
   

3. Complete these rules.
   a Like poles _________, unlike poles _________.
   b If a magnet ______________ a substance, that substance is magnetic.
   c A magnetic field is strongest where the lines of force are _________.

4. On the bar magnet opposite, draw one line of force at each end and two lines of force on each side. Write in N and S and put arrows on the lines of force to show their directions.

5. a What happens to a compass in the Earth’s magnetic field?
   
   b How does this help travellers?

6. a The Earth is drawn on maps with north at the top. Which way round is the imaginary magnet inside the Earth? Tick the correct answer.
   North Pole at the top  South Pole at the top
   
   b The diagram shows the Earth with the North Pole. Draw in the magnetic field around the Earth.
7 You have a needle and a small bar magnet.

a How would you magnetise the needle? Tick the correct answer.

- Stroke the magnet back and forth along the needle.
- Move the magnet round and round the needle.
- Stroke the magnet repeatedly in one direction along the needle.
- Move the point of the needle over the surface of the magnet.

b Describe the test for finding out if a piece of material is a magnet.


8 a Underline two items you would need to make an electromagnet.

- low voltage d.c. supply
- lamp
- switch
- coil of wire

b What three things can you do to make an electromagnet stronger?

1
2
3


c An electromagnet can be used to pick metal up and put it down. Write numbers in the boxes to put these steps in the correct order.

- Pick up the metal.
- Turn the current off.
- Turn the current on.
- Put down the metal.

9 What sort of magnet is used as a lifting magnet in a scrap yard? Circle the correct letter.

A an iron magnet
B an electromagnet
C a permanent magnet
D a weak magnet
1 a Name the four metals that a magnet will pick up.
   1 ____________ 2 ____________ 3 ____________ 4 ____________ (in any order)

   b Name two metals that a magnet will not pick up.
   1 ____________ 2 ____________ (in any order)

2 a Where is the magnetism strongest on a magnet? Underline the correct answer.
   at the top  at the ends  in the middle  underneath

   b What is the name for the part of the magnet you have underlined?
   ____________

3 Complete these rules.
   a Like poles ____________, unlike poles ____________.

   b If a magnet ____________, a substance, that substance is magnetic.

   c A magnetic field is strongest where the lines of force are
   ____________

4 On the bar magnet opposite, draw one line of force at each end and two lines of force on each side. Write in N and S and put arrows on the lines of force to show their directions.

5 a What happens to a compass in the Earth's magnetic field?
   ____________ The compass needle points towards the North Pole.

   b How does this help travellers? ____________ It shows north, so travellers can ____________ work out which direction to travel.

6 a The Earth is drawn on maps with north at the top. Which way round is the imaginary magnet inside the Earth?
   Tick the correct answer.
   North Pole at the top ☑  South Pole at the top ☐

   b The diagram shows the Earth with the North Pole. Draw in the magnetic field around the Earth.
Magnets and electromagnets (continued)

7 You have a needle and a small bar magnet.
   a How would you magnetise the needle? Tick the correct answer.
      Stroke the magnet back and forth along the needle. ☐
      Move the magnet round and round the needle. ☐
      Stroke the magnet repeatedly in one direction along the needle. ☑
      Move the point of the needle over the surface of the magnet. ☐
   b Describe the test for finding out if a piece of material is a magnet.
      Use a magnet and see if the other material is repelled or
      attracted. If it is repelled the material must be a magnet.
      (Magnets can repel; magnetic material is always attracted)

8 a Underline two items you would need to make an electromagnet.
      low voltage d.c. supply  lamp  switch  coil of wire

b What three things can you do to make an electromagnet stronger?
   1 Increase the current in the coil.
   2 Put more turns in the coil.
   3 Put a soft iron core in the coil.

c An electromagnet can be used to pick metal up and put it down.
   Write numbers in the boxes to put these steps in the correct order.
      2 Pick up the metal.
      3 Turn the current off.
      1 Turn the current on.
      4 Put down the metal.

9 What sort of magnet is used as a lifting magnet in a scrap yard? Circle
   the correct letter.
   A an iron magnet  B an electromagnet  C a permanent magnet  D a weak magnet

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This worksheet may have been altered from the original on the CD-ROM.
Magnets and electromagnets

1 The drawing shows:

- an aluminium can
- a shiny steel can
- an old can covered in iron oxide rust

a Which cans will be picked up by a magnet? 2 marks
b Which can will not be picked up by a magnet? 1 mark

2 a Explain how you would magnetise a needle using a magnet. 2 marks
b How could you test how strong a magnet the needle is? 1 mark
c There are two magnetised needles on the table, and one unmagnetised needle. Explain how you could tell which one is which. 1 mark
d Describe how you could use a coil of wire carrying an electric current to make the unmagnetised needle into a magnet. 2 marks

3 Dr Gilbert showed that in the centre of the Earth, there is a large amount of magnetic iron.

a What do we call the effect that the Earth has that makes a compass work? 1 mark
b What happens to the magnetic needle of a compass when it is allowed to move freely? 1 mark
c A compass can be used for navigation. Why is it important that no other magnets are brought near to the compass? 1 mark

4 Copy the bar magnet shown below. Show the shape and direction of the magnetic field of the magnet by drawing in the field lines with arrows. 2 marks

5 a Why is it possible to use an electromagnet to separate magnetic materials from non-magnetic materials? 2 marks
b Explain how a scrap yard uses an electromagnet to pick up a car part in one place and put it down in another. 2 marks
c You have wound an insulated wire around a wooden pencil, to make an electromagnet.

What two things could you do to increase the strength of the electromagnet? 2 marks
Katie made an electromagnet to pick up paperclips. She increased the number of turns of wire of the electromagnet and counted the number of paperclips it picked up.

Here are her results:

<table>
<thead>
<tr>
<th>Number of turns</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paperclips lifted</td>
<td>3</td>
<td>9</td>
<td>16</td>
<td>31</td>
<td>40</td>
</tr>
</tbody>
</table>

a) Katie made sure that all the paperclips were the same before she started. Why was this important? 1 mark

b) Katie said that if she had 60 turns, 50 paperclips would be lifted. Choose the type of statement she has made from this list.

- an observation
- a conclusion
- a prediction
- a measurement

Katie made another electromagnet. This time she explored what happened to the strength of the electromagnet as she increased the current flowing through it.

Here are her results:

<table>
<thead>
<tr>
<th>Current (Amps)</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paperclips lifted</td>
<td>5</td>
<td>11</td>
<td>16</td>
<td>24</td>
<td>29</td>
</tr>
</tbody>
</table>

c) Which variable is the independent (input) variable in her experiment? 1 mark

d) When Katie plotted the graph of her results, she put the values for Current along the horizontal x-axis. Why did she do this? 1 mark

e) Katie plots a graph of her results and predicts that with a current of 1.2 A her magnet will pick up 35 paperclips. How could Katie make this prediction? 1 mark
Magnetism and electromagnets

1. **Explain how you would magnetise a needle using a magnet.** 2 marks

2. There are two magnetised needles on the table, and one unmagnetised needle. Explain how you could tell which one is which. 1 mark

3. Describe how you could use a coil of wire carrying an electric current to make the unmagnetised needle into a magnet. 2 marks

Dr Gilbert showed that in the centre of the Earth, there is a large amount of magnetic iron.

a. What do we call the effect that the Earth has which makes a compass work? 1 mark

b. What happens to the magnetic needle of a compass when it is allowed to move freely? 1 mark

c. Compass cases are never made of iron. What effect does iron have on the Earth’s magnetic field to make it unsuitable for compass cases? 1 mark

3. Copy the bar magnet shown below. Show the shape and direction of the magnetic field of the magnet by drawing in the field lines with arrows. 2 marks

4. **Explain how a scrap yard uses an electromagnet to pick up a car part in one place and put it down in another.** 2 marks

b. You have wound an insulated wire around a wooden pencil to make an electromagnet. What three things could you do to increase the strength of the electromagnet? 3 marks

5. **A straight piece of wire carrying a current has a field around it.**

a. Copy the diagram of the end of the piece of wire and draw in the shape of the field. 1 mark

b. There are two other things that have a magnetic field around them similar in shape to the magnetic field around a bar magnet. What are they? 2 marks
Magnets and electromagnets (continued)

6 The particles of iron within a magnet all act as tiny magnets. The diagram shows the arrangement of the particles of iron in an unmagnetised bar.
   a Why doesn’t the iron bar shown in the diagram act as a magnet?
   Use the idea of the small particles of iron in your answer. 1 mark
   b Peter strokes a magnet along the iron bar to magnetise it.
   Copy the diagram and show the arrangement of the particles of iron when it is magnetised. 1 mark

7 Katie made an electromagnet to pick up paperclips. She explored what happened to the strength of the electromagnet as she increased the current flowing through it.

Here are her results:

<table>
<thead>
<tr>
<th>Current (Amps)</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paperclips lifted</td>
<td>5</td>
<td>11</td>
<td>16</td>
<td>24</td>
<td>29</td>
</tr>
</tbody>
</table>

   a Which variable is the independent (input) variable in her experiment?  1 mark
   b When Katie plotted the graph of her results, she put the values for Current along the horizontal x-axis. Why did she do this?  1 mark
   c Katie plots a graph and predicts that with a current of 1.2 A her magnet will pick up 35 paperclips. How could Katie make this prediction?  1 mark

   d Two of the graph points are not exactly on the graph line, but Katie is happy with these two. If one of the points were a long way from the graph line, what would it be called?  1 mark
   e Joanne said that Katie should have used 0.5 intervals for the scale on the x-axis. Why would this not be a good idea?  1 mark
## Magnets and electromagnets

### Question Answer Mark Level

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a</td>
<td>Steel can.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Rusty can.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Aluminium can.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>1 b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 a</td>
<td>Stroke the needle with the magnet in one direction.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 b</td>
<td>See how much weight or how many paper clips the needle will pick up.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2 c</td>
<td>The needle that is not repulsed by the other needles is the unmagnetised one.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 d</td>
<td>Put the needle inside the coil. Switch on the current.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3 a</td>
<td>Magnetic field.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3 b</td>
<td>It points north.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3 c</td>
<td>The magnetic field will deflect the compass giving a false reading.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td><img src="image.png" alt="Diagram of electromagnet" /></td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>(one mark for the lines, one mark for arrows N-S)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 a</td>
<td>Because an electromagnet will pick up magnetic materials but not non-magnetic materials.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 b</td>
<td>The current is switched on to make the electromagnet work to pick up and carry the part. The current is switched off to stop the electromagnetic effect and put the part down. (accept: the magnet is switched on then off)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 c</td>
<td>Any two from: Put an iron core inside the coil. Add more coils. Use a stronger current.</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>6 a</td>
<td>Make the experiment fair/some paper clips might be heavier than others.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6 b</td>
<td>A prediction.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6 c</td>
<td>Current</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>6 d</td>
<td>The independent (input) variable always goes on the x-axis.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>6 e</td>
<td>By reading from the graph/extend the graph line.</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

### Scores in the range of: NC Level

<table>
<thead>
<tr>
<th>Scores in the range of:</th>
<th>NC Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>4–7</td>
<td>3</td>
</tr>
<tr>
<td>8–13</td>
<td>4</td>
</tr>
<tr>
<td>14–17</td>
<td>5</td>
</tr>
<tr>
<td>18–25</td>
<td>6</td>
</tr>
</tbody>
</table>
Magnets and electromagnets

Question | Answer | Mark | Level
--- | --- | --- | ---
1a | Stroke the needle with the magnet in one direction. | 2 | 4
b | The needle that is not repulsed by the other needles is the unmagnetised one. | 1 | 4

1c | Put the needle inside the coil. Switch on the current. | 1 | 5

2a | Magnetic field. | 1 | 4
b | It points north. | 1 | 5

2c | Iron blocks the magnetic field. | 1 | 5

3 | [Diagram showing magnetic field lines] (one mark for the lines, one mark for arrows N–S) | 2 | 5

4a sol1 | The current is switched on to make the electromagnet work to pick up and carry the part. | 1 | 5

4a sol2 | The current is switched off to stop the electromagnetic effect and put the part down. (accept: the magnet is switched on then off) | 1 | 5

4b | Put an iron core inside the coil. Add more coils. Use a stronger current. | 1 | 6

5a | An electromagnet. The Earth. | 1 | 6

5b | [Diagram showing coil and magnetic field] (accept: one or two circles; arrows on circles in one direction or the other) | 1 | 6

6a | Because all the particles of iron are randomly arranged or are not lined up or point in different directions. | 1 | 7

6b | [Diagram showing magnetic field lines] | 1 | 7

7a | Current | 1 | 5

7b | The independent (input) variable always goes on the x-axis. | 1 | 5

7c | By reading from the graph/ extending the graph line. | 1 | 5

7d | Anomalous | 1 | 6

7e | The interval would be too big/it would make it difficult to plot the points accurately. | 1 | 6

Scores in the range of: | NC Level
--- | ---
5–9 | 4
10–14 | 5
15–18 | 6
19–25 | 7
## Learning outcomes

<table>
<thead>
<tr>
<th>I can explain that magnets attract magnetic materials.</th>
<th>I can do this very well</th>
<th>I can do this quite well</th>
<th>I need to do more work on this</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can identify iron, steel, nickel, cobalt and iron oxide as magnetic materials.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can state the rule for attraction and repulsion for magnets.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can explain that repulsion is the only test for a magnet.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>I can explain that there is a magnetic field around a magnet.</td>
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<tr>
<td>I can state that magnetic substances block magnetic fields.</td>
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<tr>
<td>I can explain that the Earth has a magnetic field like a bar magnet with its N pole in the southern hemisphere.</td>
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<tr>
<td>I can make a magnet by stroking a strip of iron or steel.</td>
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<td>I can explain that steel keeps its magnetism but iron loses it as soon as the magnetising force is removed.</td>
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<tr>
<td>I can use a coil of wire carrying a direct current to make an electromagnet.</td>
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<td>I can draw the magnetic field around a solenoid and know that it is similar to that around a bar magnet.</td>
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<tr>
<td>I can plan and carry out an investigation on how to make an electromagnet stronger.</td>
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## Glossary: Magnets and electromagnets

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
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<tbody>
<tr>
<td>attract</td>
<td>Pulling force between magnets and some metals.</td>
</tr>
<tr>
<td>bar magnet</td>
<td>Materials that are attracted to a magnet.</td>
</tr>
<tr>
<td>compass</td>
<td>Pushing away force between magnets.</td>
</tr>
<tr>
<td>core</td>
<td>The two different ends of a magnet.</td>
</tr>
<tr>
<td>electromagnet</td>
<td>One end of a magnet. It attracts the south pole of another magnet.</td>
</tr>
<tr>
<td>iron filings</td>
<td>One end of a magnet. It attracts the north pole of another magnet.</td>
</tr>
<tr>
<td>key variables</td>
<td>The space around a magnet where it attracts and repels.</td>
</tr>
<tr>
<td>lodestone</td>
<td>Tiny shavings of iron used to show a magnet’s magnetic field.</td>
</tr>
<tr>
<td>magnetic field</td>
<td>A rectangular magnet.</td>
</tr>
<tr>
<td>magnetic field lines</td>
<td>The magnetic field around a magnet. Magnetic field lines run from the north pole of a magnet to its south pole.</td>
</tr>
<tr>
<td>magnetic materials</td>
<td>Instrument used for navigation, with a magnetic needle which points to the Earth's North Pole unless there is a magnet close by.</td>
</tr>
<tr>
<td>magnetic shielding</td>
<td>To plan directions to find the way.</td>
</tr>
<tr>
<td>navigate</td>
<td>'Stopping' a magnetic field by putting the magnet inside (but not touching) a box made of magnetic material.</td>
</tr>
<tr>
<td>north pole</td>
<td>Iron oxide, a natural magnet.</td>
</tr>
<tr>
<td>permanent magnet</td>
<td>A material that only acts as a magnet when it is in a magnetic field.</td>
</tr>
<tr>
<td>poles</td>
<td>A material that stays as a magnet for many years.</td>
</tr>
<tr>
<td>repel</td>
<td>A magnet that can be switched on and off using electricity.</td>
</tr>
<tr>
<td>solenoid R</td>
<td>A coil of wire with an electric current running through it that creates a magnetic field.</td>
</tr>
<tr>
<td>south pole</td>
<td>Magnetic material placed inside a coil of wire (with an electric current running through it), to make the magnetic field stronger.</td>
</tr>
<tr>
<td>temporary magnet</td>
<td>Variables that will have a large effect in an investigation.</td>
</tr>
</tbody>
</table>
Magnets and electromagnets

- attract
- bar magnet
- compass
- core
- electromagnet
- iron filings
- key variables
- lodestone
- magnetic field
- magnetic field lines
- magnetic materials
- magnetic shielding
- navigate
- north pole
- permanent magnet
- poles
- repel
- solenoid
- south pole
- temporary magnet

Key words
### J Magnets and electromagnets

#### J1 Magnetic fields

**Green**

a. They would not stick to the door.
b. Put a magnet on it. If it sticks, the can is iron; if it doesn't stick, the can is aluminium.
c. The iron filings make lines. They show the magnetic field around the magnet.

1. Magnets have two ends called ... the North Pole and South Pole.  
   The closer you are to the magnet ... the stronger the magnetic field.  
   Where magnets push or pull is called ... a magnetic field.  
   Iron, steel, cobalt, nickel and iron oxide ... are all magnetic materials.  
   Unlike poles attract ... and like poles repel.

2. The 2p coin and steel key.

3. a. Put a sheet of paper on the magnet and sprinkle iron filings on the paper.
   b. The magnetic field is stronger closer to the magnet.

**Red**

a. They would not stick to the door.
b. Put a magnet on it. If it sticks, the can is iron; if it doesn't stick, the can is aluminium.
c. Put a magnet on each one. If the magnet sticks, then it is the piece of nickel. If the magnet doesn't stick, then it's the piece of aluminium.

d. The magnetic field lines are invisible.
e. At the poles.

1. Any one of: there are more magnetic lines of force at the poles, the magnetic lines of force are closer together at the poles, there are more iron filings at the poles.

2. Individual answers that involve sprinkling iron filings in a suitable way.

#### J2 Magnets

**Green**

a. To the south.
b. Weather has no effect on magnets or magnetic fields.

**Red**

a. i. downwards  
   ii. upwards

1. Place compasses around the magnet on a piece of paper. Draw arrows on the paper showing the direction that each compass needle is pointing. Remove the compasses and draw curved lines connecting each compass to the nearest pole of the magnet.

2. If compasses always point north, then there must be a south pole of a magnet at the geographic north end of the Earth. Standing at the geographic ends of the Earth makes the compass needles point downwards at the geographic North Pole and upwards at the geographic South Pole.
J3 Making magnets

Green

a i Iron oxide. ii steel iii iron
b So that the needle can turn in any direction.
c The needle was made into a magnet.
d Lumps 2 and 5. They were the only ones which repelled one of the poles of John’s permanent magnet. The other lumps were attracted by both poles of John’s magnet. This meant that they were magnetic materials but not themselves magnets.

1. Two magnets can ... attract and repel. Steel in a magnetic field ... becomes a temporary magnet. A magnet and some magnetic material ... always attract. Iron in a magnetic field ... becomes a weak permanent magnet.

2. Individual answers which include the procedure outlined on pages 104–105.

Red

a So that the needle can turn in any direction.
bi All the particles have their north poles pointing in the same direction.
ii The particles have their north poles pointing in all different directions.
iii All the particles have their north poles pointing in the same direction.

c All the particles have their north poles pointing in the same direction.
1. The particles in the iron can turn and point their north poles in the same direction.
2. The paperclip touching the magnet becomes a magnet by turning its particles so that the north poles are in the same direction. This then causes the same effect on the next paperclip, and so on.
3. Stroking the steel needle with a magnet causes the particles in the needle to turn so that they all have their north poles pointing in the same direction.
4. When iron is taken out of a magnetic field, all the particles turn so that their north poles are pointing in all different directions.
5. All the particles in lodestone always have their north poles pointing in the same direction.

2 a Hitting the magnet hard shakes the particles so that they have their north poles pointing in all different directions.

b The stronger magnets will cause some of the particles in the weaker magnets to turn so that they have their north poles pointing in different directions.

J4 Electromagnets

Green

a Any three from: wood, plastic, glass, paper, aluminium, etc.
b The metals attracted to the electromagnet will fall off.
c To the Earth’s North Pole.
d The keys would fall off the electromagnet.
e As the number of turns in the coil increases, the strength of the electromagnet increases.
f They would have to keep the number of turns in the electromagnet constant and use the same core in their investigation.

1. A coil of wire has a magnetic field around it when the current is switched on. An electromagnet has an iron core inside. You can make an electromagnet stronger by increasing the number of turns in the coil, or increasing the current.

2. It can be switched on and off when required.

Red

a Any three from: wood, plastic, glass, paper, aluminium, etc.
b The electromagnet can pick up some metal objects and they can be moved to a different place by switching off the current.
c To the Earth’s North Pole.
di Using more turns in the coil will add more magnetic field lines and therefore make the magnet stronger.
ii A higher current will make more of the particles in the iron turn so that their north poles are pointing in the same direction and therefore it becomes a stronger magnet.
e The electromagnet loses its magnetism and the spring pulls the iron bolt back to lock the door.

1. a

2. The cars cannot be moved about using electromagnets. Aluminium is not magnetic.

3. Individual answers. These should include the idea that the magnetic field lines pass through the iron and cause the particles in the iron rod to turn so that they all have their north poles pointing in the same direction.
J5 Variables

Green

a Input (independent) variables: thickness of wire, number of turns in coil, material of core, length of core, type of wire, thickness of core, current.

b Number of turns in coil, material of core and current.

c Make a list of the other input variables in order of their importance to the strength of the electromagnet, starting with the most important.

d No. The different cores produced different strengths of electromagnets which picked up different numbers of paperclips.

e i A bar chart. ii A graph. iii A graph.

f Yes. A graph using different cores on one axis could not be drawn.

g Individual answers, such as using more cores, tiny washers for weighing, different diameters of cores, etc.

h A core made of cobalt or iron oxide.

1 Increasing the number of turns in the coil of an electromagnet increases the strength of the electromagnet.

2 Priya’s method is better. The strength of the electromagnet can be changed by small amounts by changing the number of turns in the coil.

Red

a Possible input (or independent) variables: thickness of wire, length of wire, width of coil, number of turns in coil, material of core, length of core, type of wire, thickness of core, mass of core, current.

b Number of turns in coil, material of core and current.

c Make a list of the other input variables in order of their importance to the strength of the electromagnet, starting with the most important.

d No. The different cores produced different strengths of electromagnets which picked up different numbers of paperclips.

e i A bar chart. ii A graph. iii A graph.

f Yes. A graph using different cores on one axis could not be drawn.

g Individual answers, such as using more cores, tiny washers for weighing, different diameters of cores, etc.

h A core made of cobalt or iron oxide.

1 Increasing the number of turns in the coil of an electromagnet increases the strength of the electromagnet.

2 Mrs Futter. Smaller masses would have made his measurements more accurate.

3 Kevin’s method. He could adjust the strength of the electromagnet to any value by simply changing the current. His results produced the largest change of the strength of the electromagnet.