Section

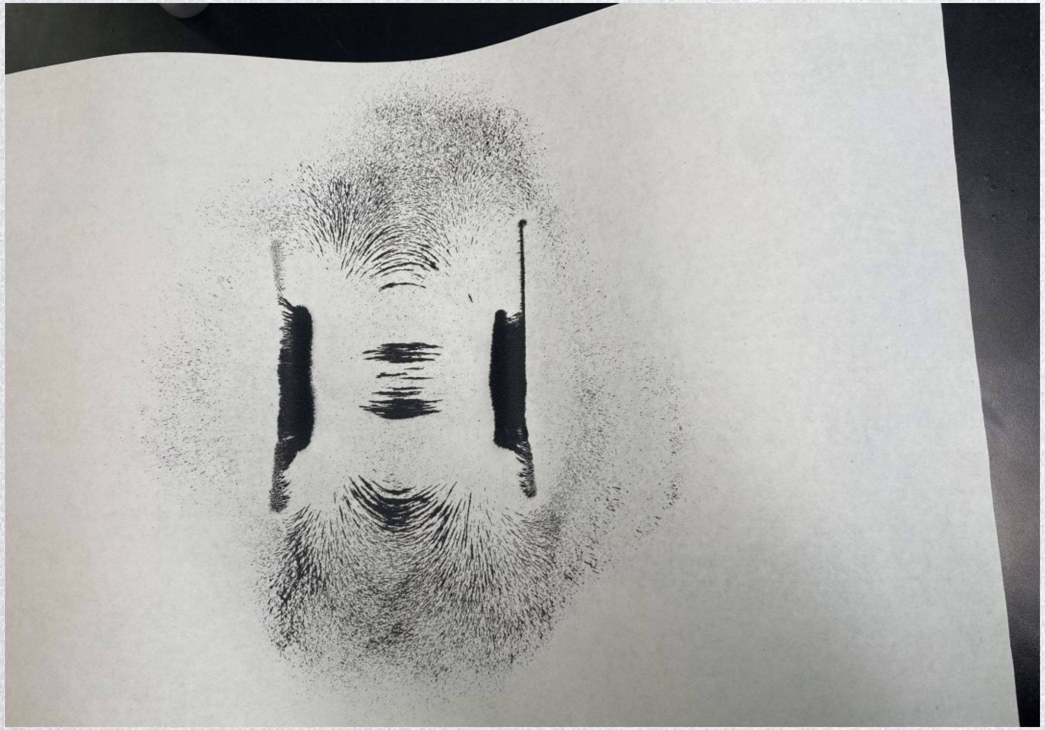
4.1

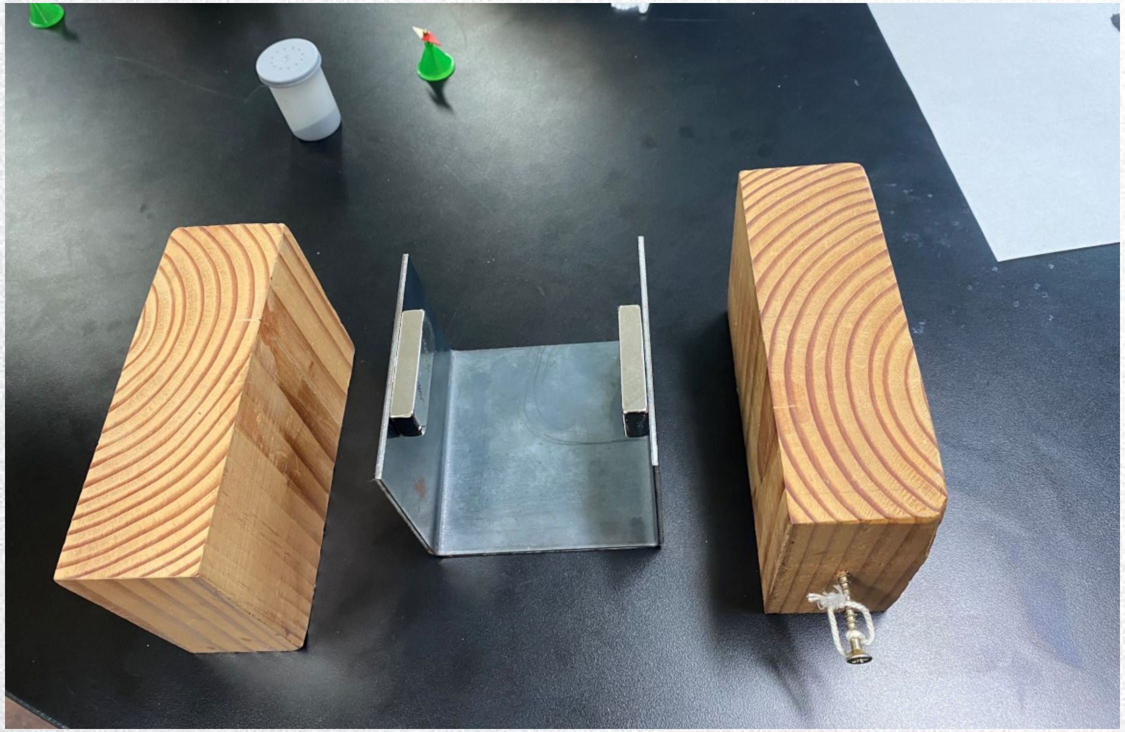
# Magnetism

4.1.1 Permanent magnets

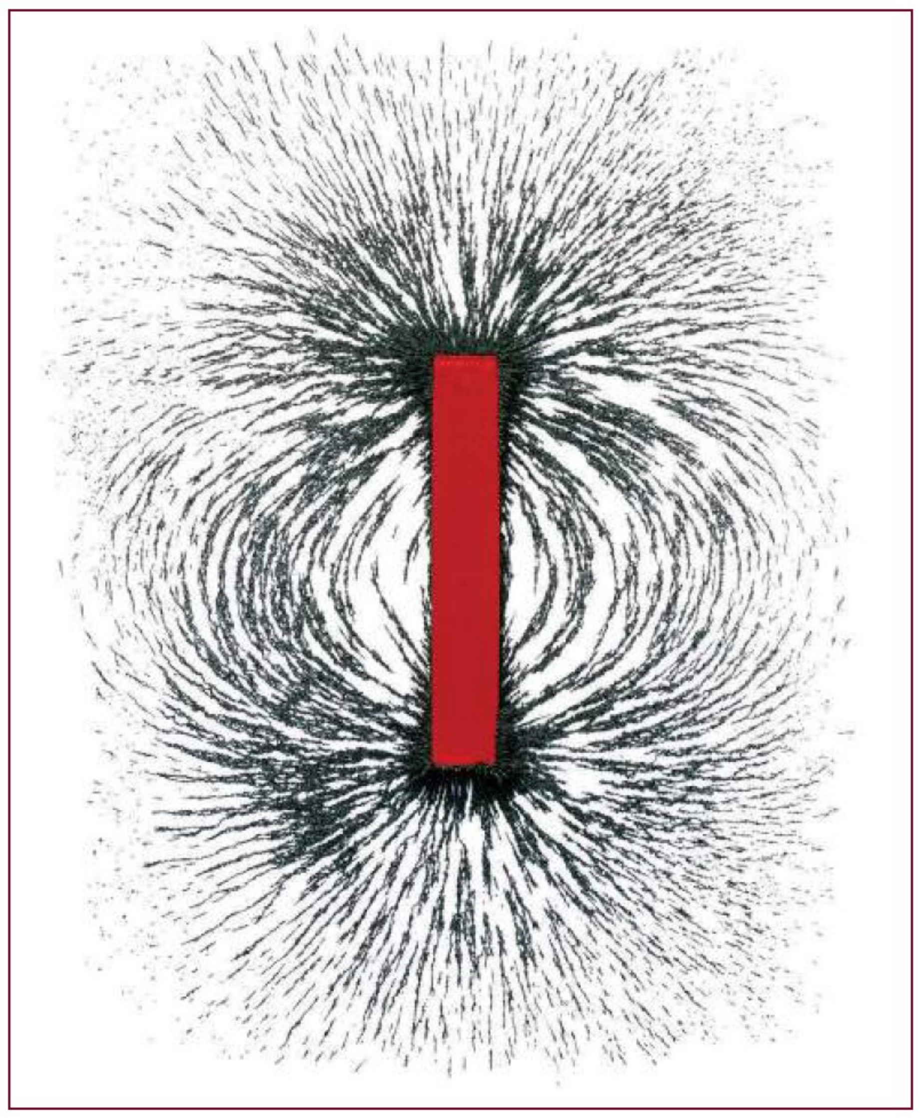
4.1.2 **Magnetic fields**

# Magnets & Magnetic Fields





# Magnets & Magnetic Fields



The magnetic field pattern of a bar magnet is shown up by iron filings. The iron filings cluster most strongly around the two poles of the magnet. This is where the field is strongest.

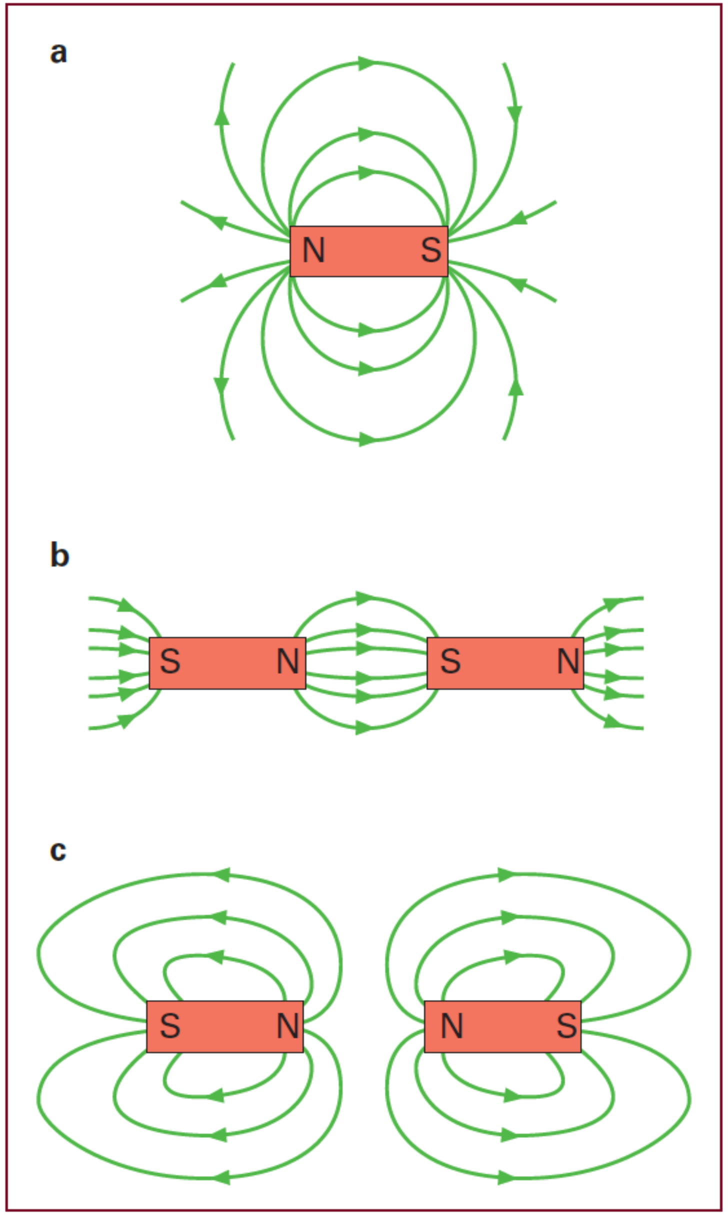
# Magnets & Magnetic Fields

The magnetic field of a single bar magnet can be represented by using **magnetic field lines**. The field fills all the space around the magnet, but we can only draw a selection of typical lines to represent it.

The pattern tells us two things about the field:

- ***Direction***. If you were to place a tiny compass at a point in the field, it would align itself along the field line at that point. We use a convention that says that **field lines come out of north poles and go in to south poles**.
- ***Strength***. Lines **close** together indicate a **strong** field.

# Magnets & Magnetic Fields




We can also show the field patterns for two magnets attracting (Figure b) and repelling (Figure c) each other.

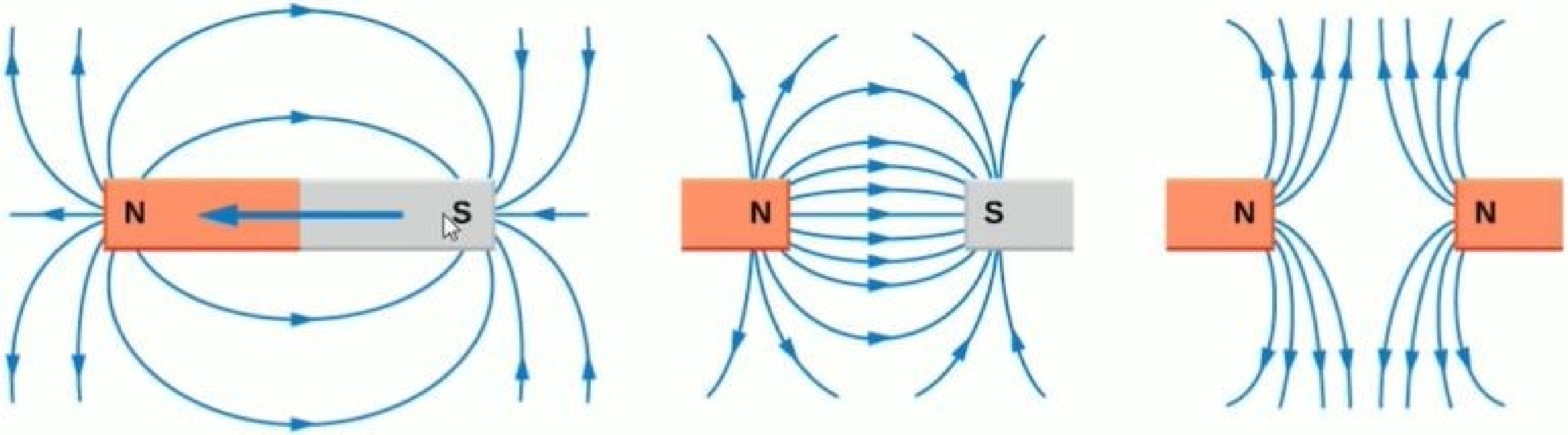
a. Field lines are used to represent the magnetic field around a bar magnet.

b. The attraction between two opposite magnetic poles shows up in their field pattern.

c. The field pattern for two like poles repelling each other.

*Notice that there is a point between the **two repelling magnets** where there is **no magnetic field**.

# Magnetic Field Lines




Magnetic field lines of a bar magnet

(a)

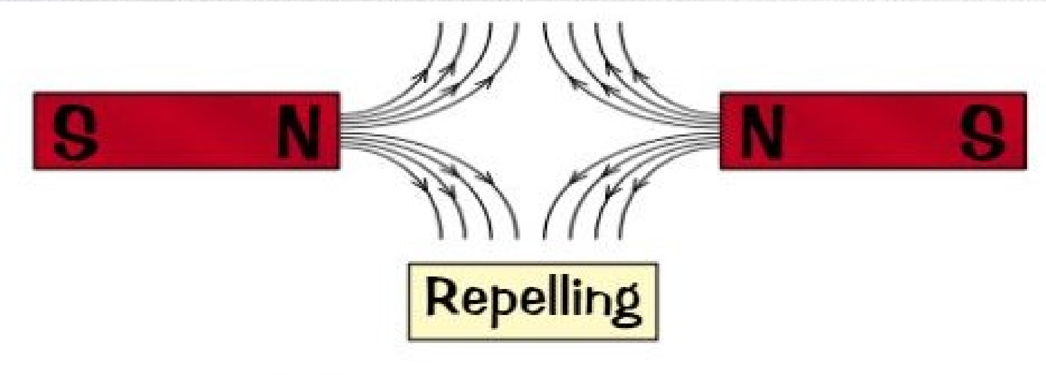
Magnetic field lines between unlike poles

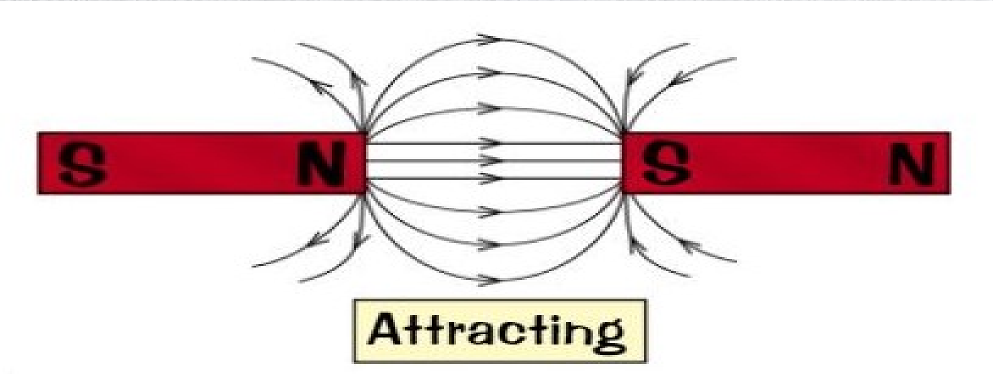
(b)

Magnetic field lines between like poles

(c)

# Magnets & Magnetic Fields

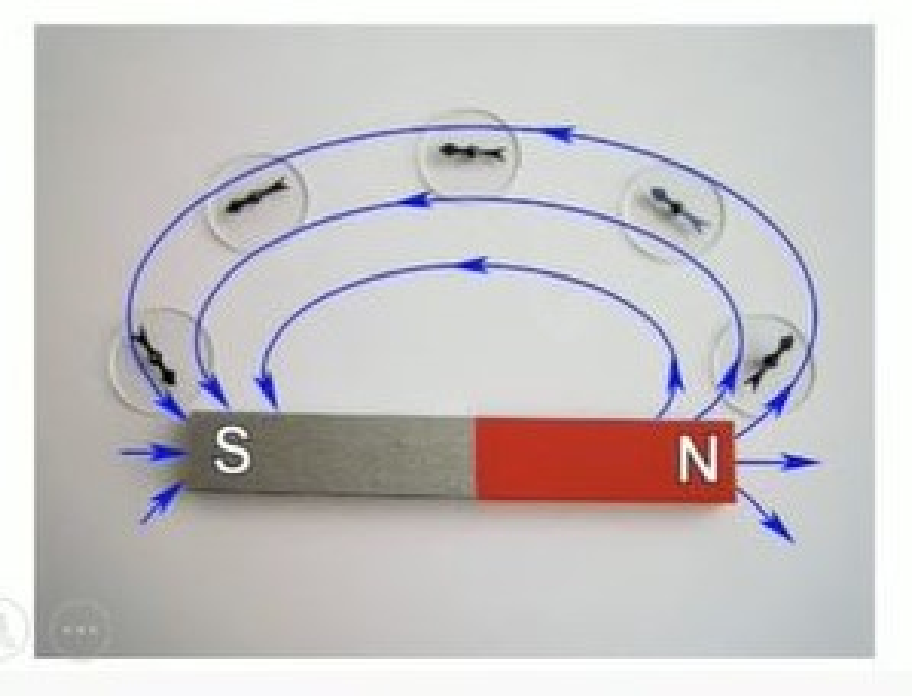


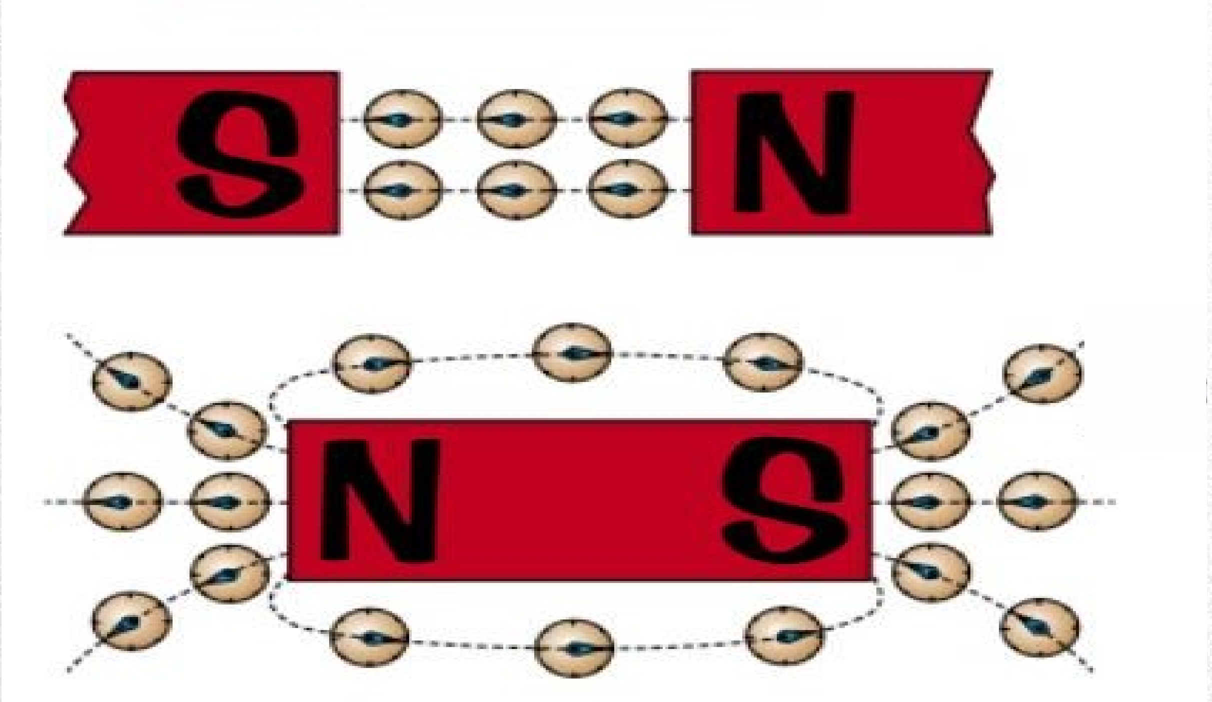




- Magnets affect magnetic materials and other magnets.
- **Like poles repel** each other and **opposite poles attract**. Both poles attract magnetic materials (that aren't magnets).

# Plotting field lines

# Plotting field lines



# Plotting field lines

**Iron filings** can show up the pattern of the magnetic field around a magnet. Place the magnet under a stiff sheet of plain paper or (preferably) clear plastic. Sprinkle filings over the paper or plastic. Tap the paper or plastic to allow the filings to move slightly so that they line up in the field.

An alternative method of doing this uses a small **compass** called a plotting compass. When a plotting compass is placed in a magnetic field, its needle turns to indicate the direction of the field.

# Plotting field lines

- You could use **iron filings** to see magnetic field patterns. Just put the magnets under a piece of paper, scatter the iron filings on the top, and tap the paper until the iron filing form a clear pattern.
- Magnetic field patterns can be also seen using **compasses**:

1) Compasses and iron filings align themselves with magnetic fields.
2) You can use multiple compasses to see the magnetic filed lines coming out of a bar magnet or between two bar magnets.

* You **shouldn't put the compasses too close to each other**, because compasses also produce magnetic fields – you need to make sure you're measuring the field of the magnet rather than the compasses nearby.

* If you don't have lots of compasses, you can just use one and move it around – trace its position on a paper before each move if it helps.

# Magnetic field & Magnetic field lines

- A **magnetic field** is a region where magnetic materials (e.g. iron) experience a force.
- **Magnetic forces** are due to interactions between magnetic fields.
- **Magnetic field lines** (lines of force) are used to show the size and direction of magnetic fields. They always point **from north (N) to south (S)**.
- The **direction of a magnetic field** at a point is the direction of the force on the N pole of a magnet at that point.
- Placing the north and south poles of two permanent bar magnets near each other creates a **uniform field** between the two magnets (until demagnetized).
- The **relative strength of a magnetic field** is represented by the **spacing of the magnetic field lines**.

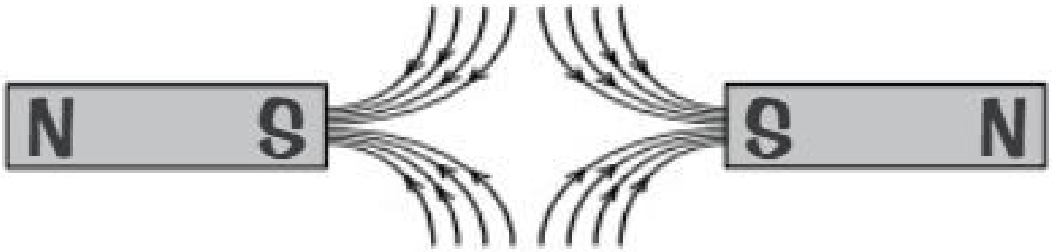
# Study question #1

Sketch the magnetic field pattern between two magnets that are lined up next to each other with their south poles close together.

# Study question #1

Sketch the magnetic field pattern between two magnets that are lined up next to each other with their south poles close together.

E.g.

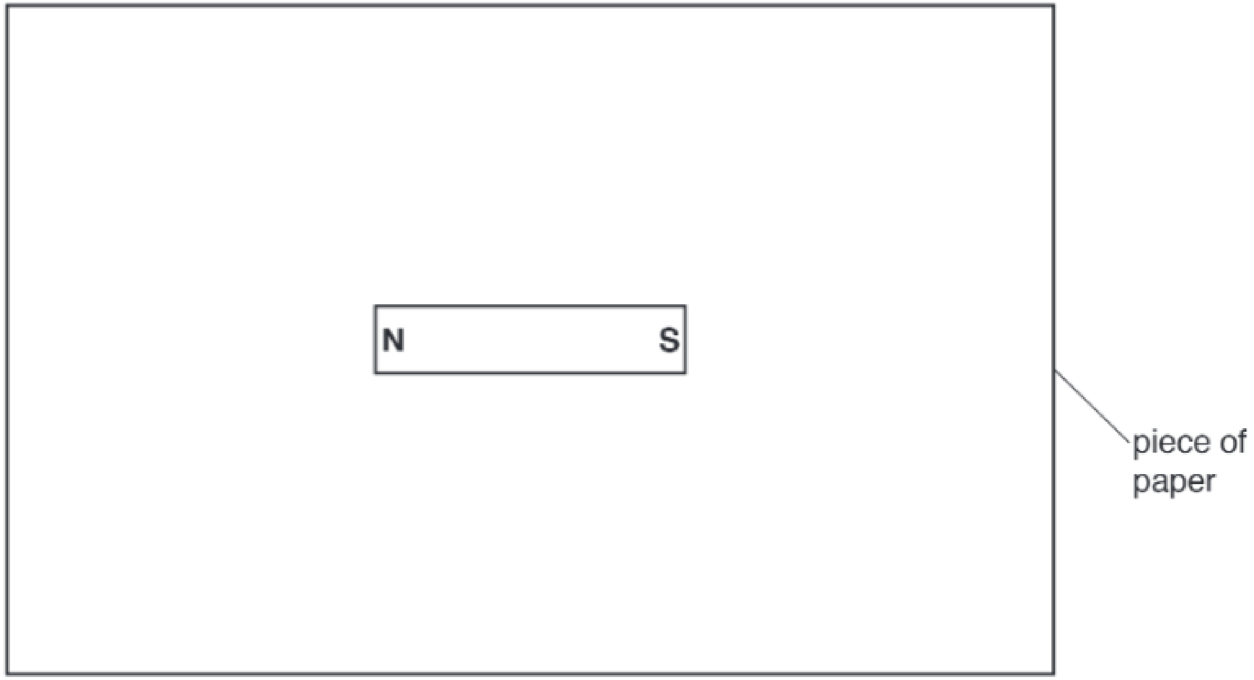



*[1 mark for correctly drawn lines, 1 mark for arrows drawn pointing towards the poles]*

# Study question #2

A student is experimenting with magnets and electric charges.

The student places a bar magnet on a piece of paper, as shown in the diagram.




Show the pattern of magnetic field lines around the bar magnet.

Draw **two** lines above the magnet and **two** lines below the magnet. Start and finish each line at a pole. Include **one** arrow to show the direction of the magnetic field.

[3]

# Study question #2

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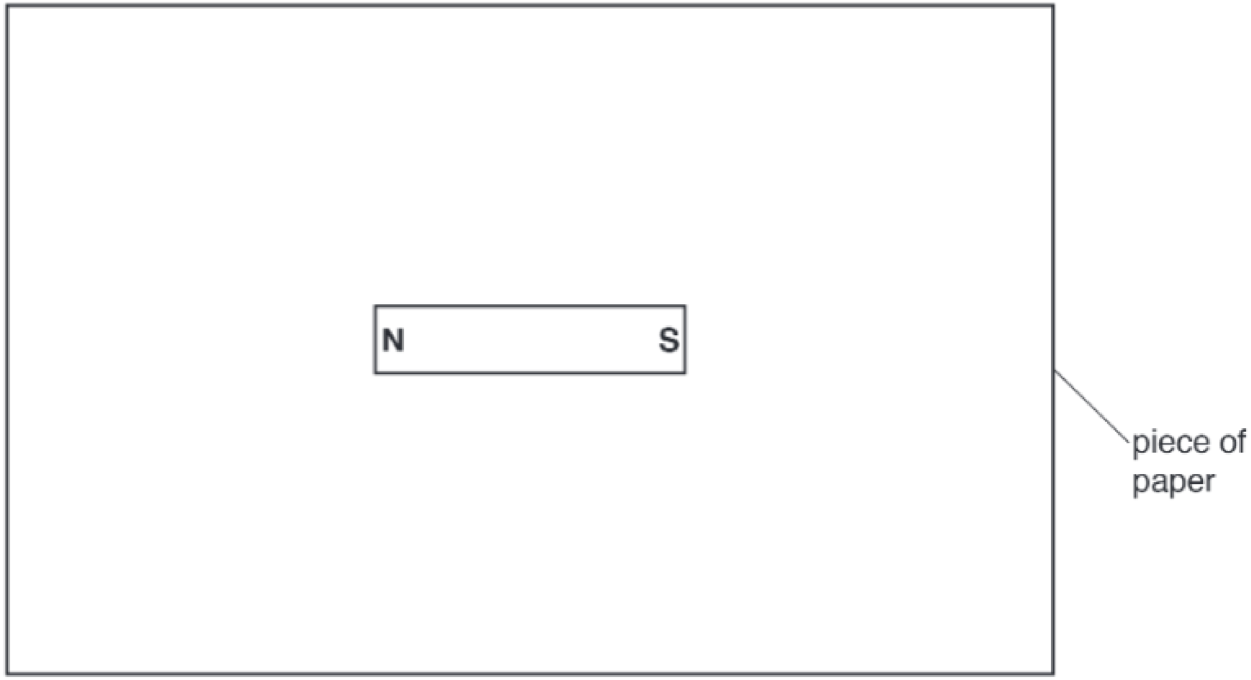



Show the pattern of magnetic field lines around the bar magnet.

Draw **two** lines above the magnet and **two** lines below the magnet. Start and finish each line at a pole. Include **one** arrow to show the direction of the magnetic field.

[3]

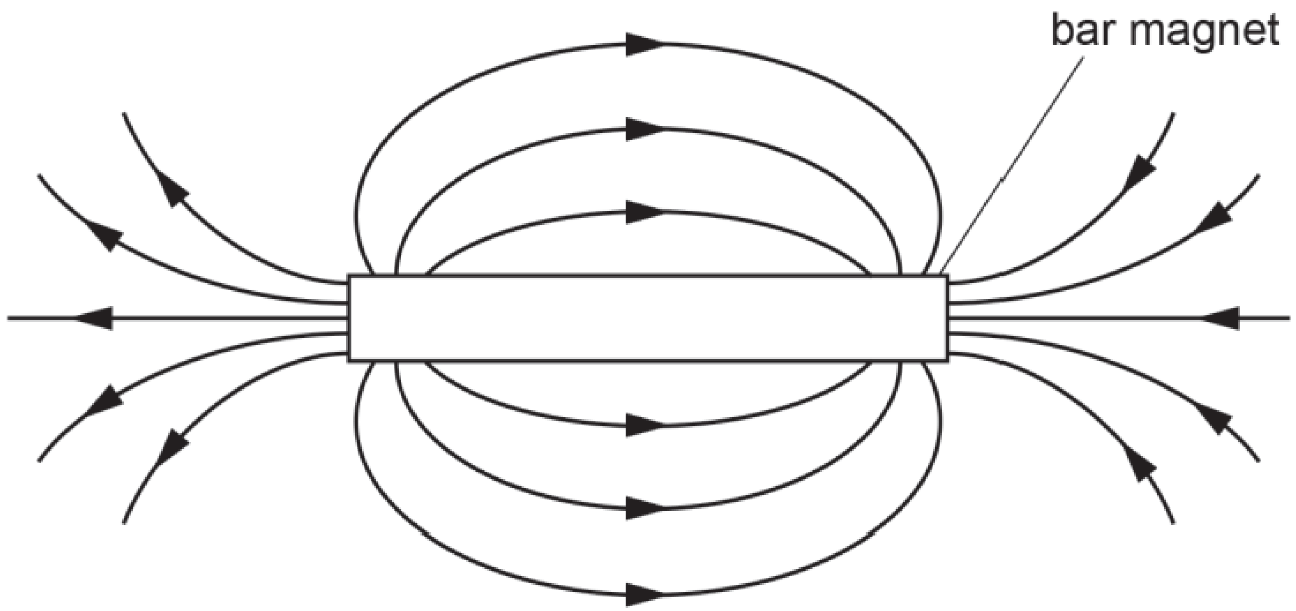
correct field pattern for bar magnet (1)

no lines crossing and good detail of curvature (1)

correct direction of arrow i.e. out from N pole (1)

# Study question #3

The diagram shows the magnetic field pattern around a bar magnet.



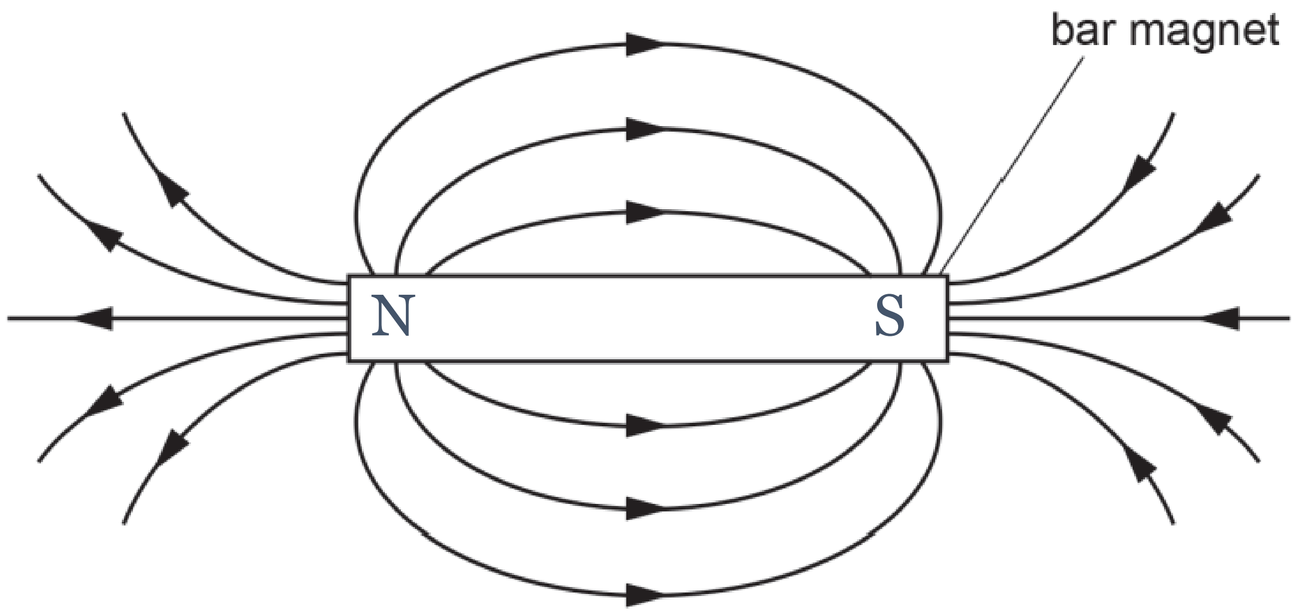

On the diagram, write the letters N and S to indicate the north and south poles of the magnet.

[1]

[Total: 1]

# Study question #3

The diagram shows the magnetic field pattern around a bar magnet.



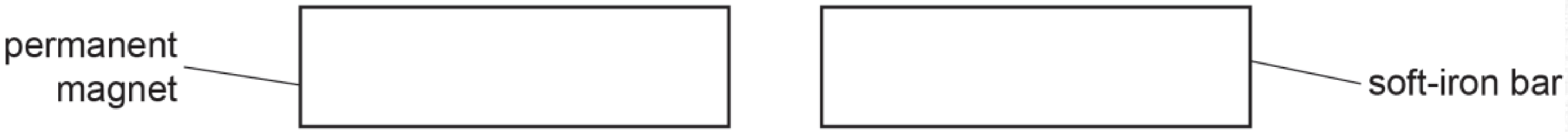

On the diagram, write the letters N and S to indicate the north and south poles of the magnet.

[1]

[Total: 1]

# Study question #4

The diagram shows a soft-iron bar placed close to a permanent magnet.




State and explain what happens to the soft-iron bar. You may draw on the diagram.

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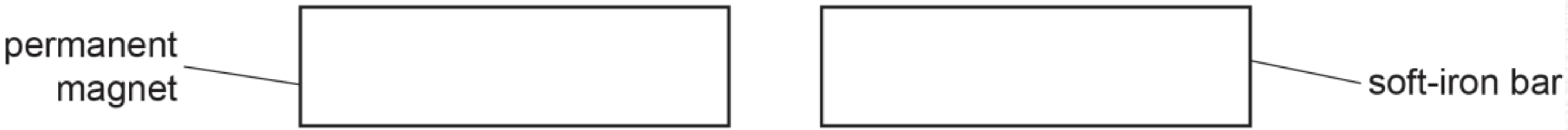
............................................................................................................................................. [3]

[Total: 3]

# Study question #4

The diagram shows a soft-iron bar placed close to a permanent magnet.




State and explain what happens to the soft-iron bar. You may draw on the diagram.

iron bar and magnet attract each other (1)

iron bar becomes an induced magnet (1) with opposite pole next

to pole of magnet (1) [3]

[Total: 3]

# Study question #5

Identify which of the following metals can be permanently magnetised. Place a tick (✓) in the box next to any correct metal.

- ☐ aluminium
- ☐ copper
- ☐ steel
- ☐ tungsten

[1]

[Total: 1]

# Study question #5

Identify which of the following metals can be permanently magnetised. Place a tick (✓) in the box next to any correct metal.

- [ ] aluminium
- [ ] copper
- [x] steel
- [ ] tungsten

[1]

[Total: 1]

# Study question #6

Two bar magnets are placed next to each other as shown in the diagram.


Magnet A is slowly moved towards magnet B. This causes magnet B to move away from magnet A.

**(a)** On the diagram, suggest the poles of each bar magnet.

Label N and S on each of the magnets.

[1]

**(b)** State the term used to describe the direction of the forces acting between magnet A and magnet B.

.................................................................................................................................... [1]

# Study question #6

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Magnet A is slowly moved towards magnet B. This causes magnet B to move away from magnet A.

**(a)** On the diagram, suggest the poles of each bar magnet.

Label N and S on each of the magnets.

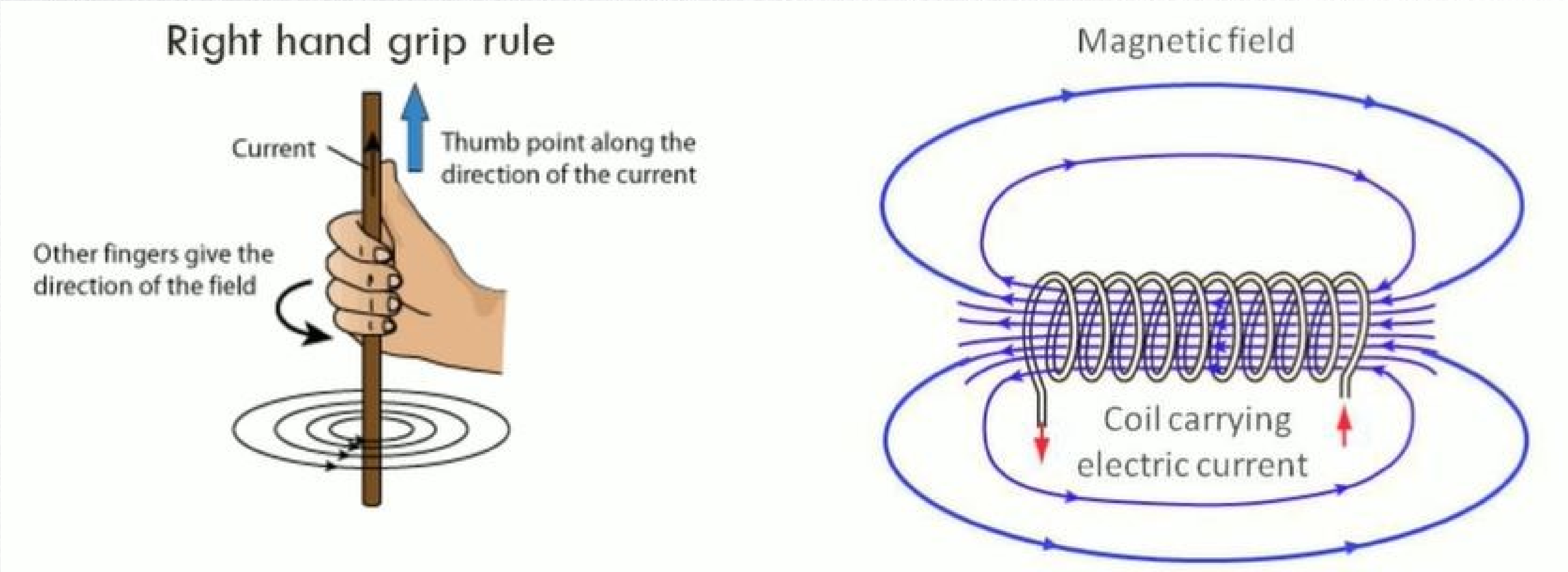
[1]

**(b)** State the term used to describe the direction of the forces acting between magnet A and magnet B.

repel / repulsion

............................................................................................................ [1]

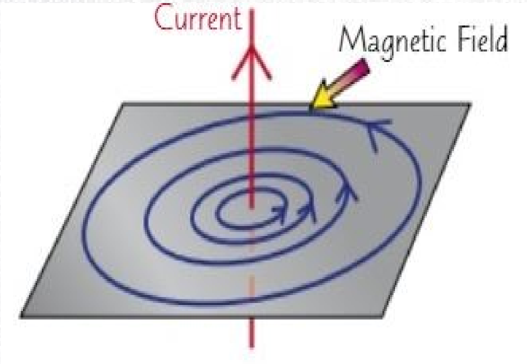
# Magnetic Field in A Wire



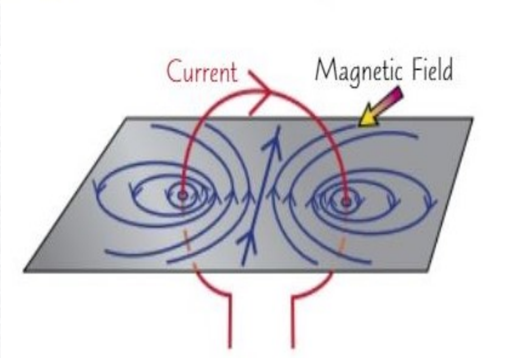

- **Current** flowing through a straight wire will also **produce a magnetic field** that is identical to a **bar magnet**.

# Magnetic Field in A Wire

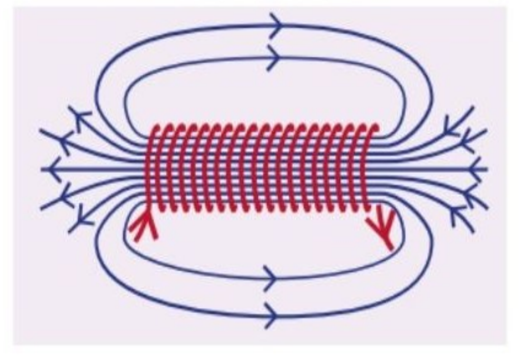
*The magnetic field around a **straight wire**:*



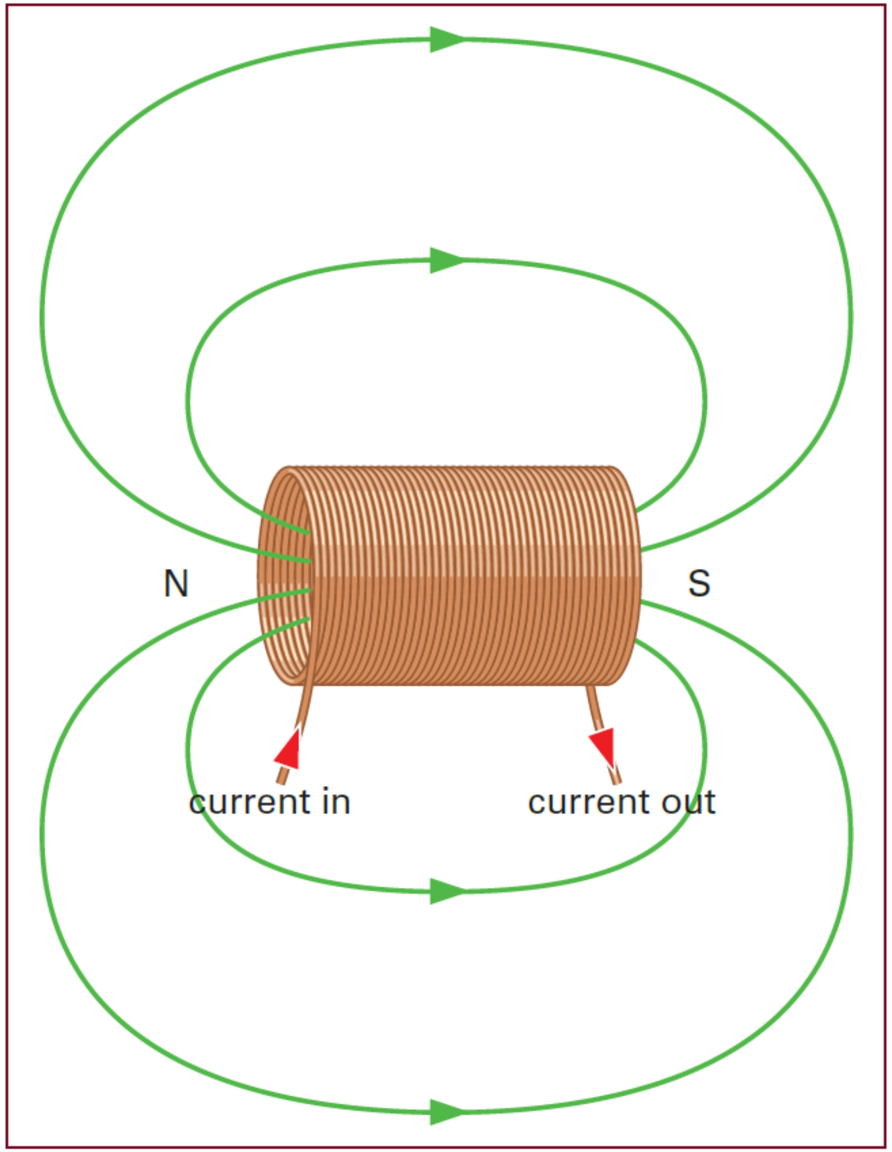

*The magnetic field around a **flat circular coil**:*




*The magnetic field around a **solenoid**:*



# Electromagnets




A **solenoid**.

When a current flows through the wire, a magnetic field is produced. The field is similar in shape to that of a **bar magnet**.

*Note that the field lines go all the way through the centre of the coil.

# Electromagnets

Using magnetic materials is only one way of making a magnet.

An alternative method is to use an **electromagnet**. A typical electromagnet is made from **a coil of copper wire**. A coil like this is sometimes called a **solenoid**. When a current flows through the wire, there is a magnetic field around the coil. **Copper wire** is often used, because of its **low resistance**, though other metals will do. The coil does not have to be made from a magnetic material. The point is that it is **the electric current that produces the magnetic field**.

You can see that the magnetic field around a solenoid is similar to that around **a bar magnet**. One end of the coil is **a north pole**, and the other end is **a south pole**.

The field lines emerge from the left-hand end, so this is the north pole (see the previous slide).

# Electromagnets

There are 3 ways to **increase the strength of an electromagnet**:

- **increase the current** flowing through it – the greater the current, the greater the strength of the field
- **increase the number of turns of wire on the coil** – this does not mean making the coil longer, but **packing more turns into the same space** to concentrate the field
- **add a soft iron core** – an iron core becomes strongly magnetised by the field, and this makes the whole magnetic field much stronger.

# Electromagnets

Electromagnets have the great advantage that they **can be switched on and off**.

Simply switch off the current and the field around the coil disappears.

This is the basis of a number of applications – for example, the **electromagnetic cranes** that move large pieces of metal and piles of scrap around in a scrapyard.

The current is switched on to energise the magnet and pick up the scrap metal. When it has been moved to the correct position, the electromagnet is switched off and the metal is released. Electromagnets are also used in **electric doorbells**, **loudspeakers**, **electric motors**, **relays** and **transformers**.

# Electromagnets

Using an electromagnet in a scrapyard.

With the current switched on, a steel object or pile of scrap can be lifted and moved. Then the current is switched off to release it.

# Study question #5

Describe how to make an electromagnet. You may draw a labelled diagram to help your answer.

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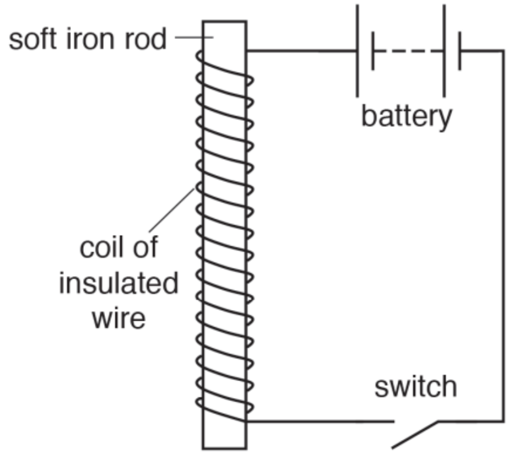
[Total: 3]

# Study question #5

Describe how to make an electromagnet. You may draw a labelled diagram to help your answer.



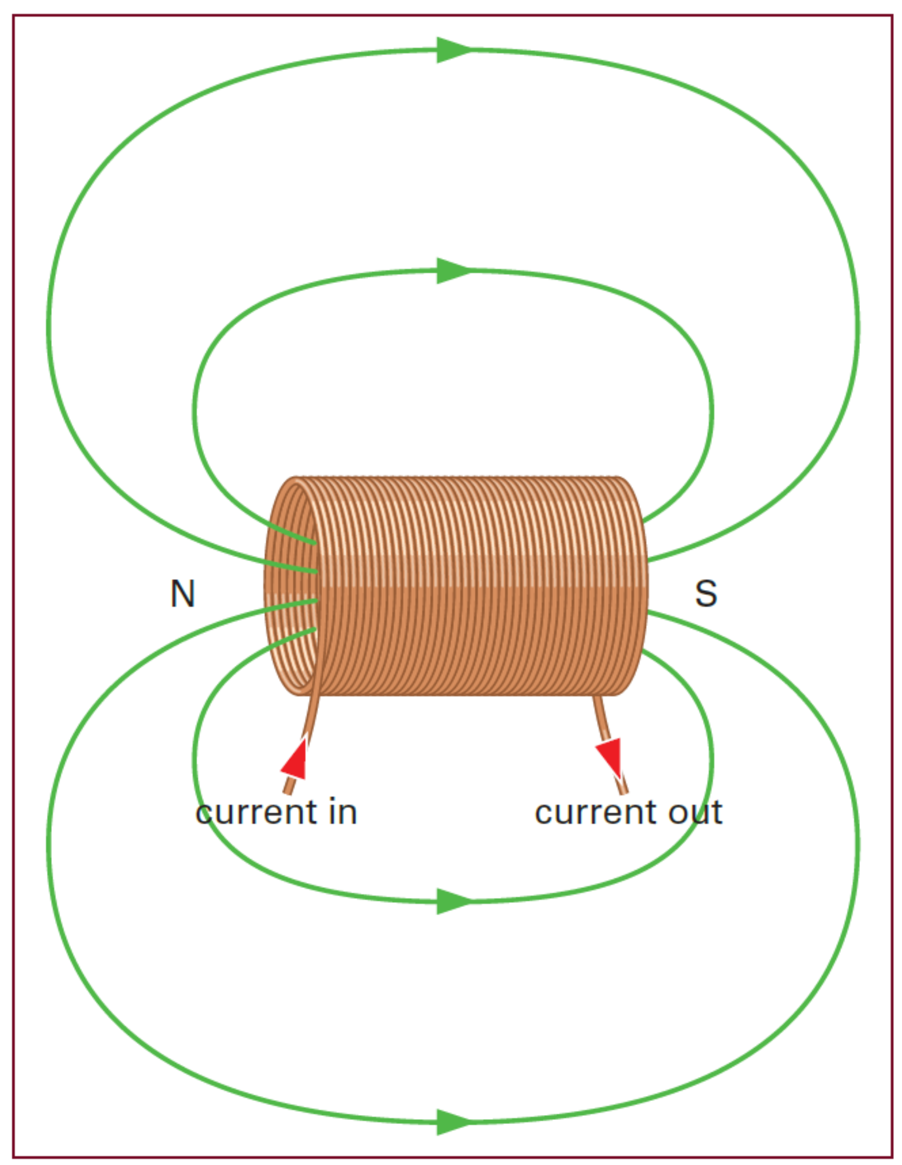

coil of wire [1] iron rod inside [1] coil connected to an (electrical)

power supply OR current in coil [1]

[3]

[Total: 3]

# The field around a solenoid



# The field around a solenoid

When an electric current flows through a solenoid, a magnetic field is produced inside and outside the coil. This field is similar to that around a bar magnet:

- One end of the solenoid is the **north pole** and the other end is the **south pole**. Field lines **emerge from the north pole and go into the south pole**.
- The **field lines are closest together at the poles**, showing that this is where the magnetic field is strongest.
- The **lines spread out from the poles**, showing that the field is weaker in these regions.
- **The field can be reversed by reversing the direction of the current**.

**Note: Magnetic field lines always **come out of a north pole** and **go into a south pole**.*

# THANK YOU