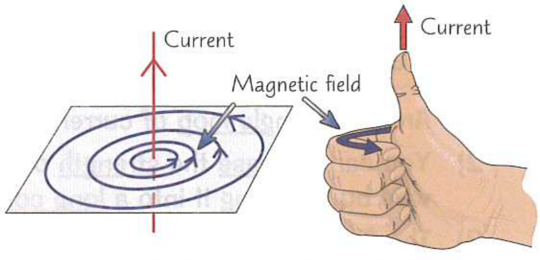
Electromagnetism and the Motor Effect

On this page you'll see that a magnetic field is also found around a wire that has a current passing through it.

A Moving Charge Creates a Magnetic Field

1) When a current flows through a long, straight conductor (e.g. a wire) a magnetic field is created around it.
2) The field is made up of concentric circles perpendicular to the wire, with the wire in the centre.
3) Changing the direction of the current changes the direction of the magnetic field — use the right-hand thumb rule to work out which way it goes. (In experiments, you can use a plotting compass to find its direction, p.195.)
4) The larger the current through the wire, or the closer to the wire you are, the stronger the field is.

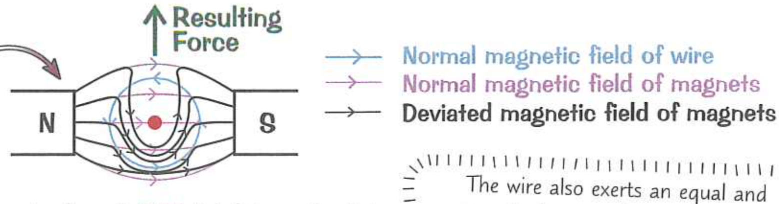


The Right-Hand Thumb Rule
Using your right hand, point your thumb in the direction of current and curl your fingers. The direction of your fingers is the direction of the field.

The Motor Effect — A Current in a Magnetic Field Experiences a Force

When a current-carrying conductor (e.g. a wire) is put between magnetic poles, the two magnetic fields interact. The result is a force on the wire.

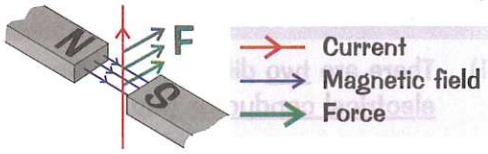
This is an aerial view. The red dot represents a wire carrying current "out of the page" (towards you). (If it was a cross ('×') then that would mean the current was going into the page.)

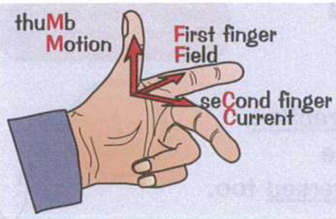


1) To experience the full force, the wire has to be at 90° (right angles) to the magnetic field. If the wire runs along the magnetic field, it won't experience any force at all. At angles in between, it'll feel some force.

The wire also exerts an equal and opposite force on the magnet (from Newton's Third Law, see p.152) but we're just looking at the force on the wire.

2) The force always acts in the same direction relative to the magnetic field and the direction of the current in the wire. So changing the direction of either the magnetic field or the current will change the direction of the force.





1) Fleming's left-hand rule is used to find the direction of the force on a current-carrying conductor.
2) Using your left hand, point your First finger in the direction of the magnetic Field and your seCond finger in the direction of the Current.
3) Your thuMb will then point in the direction of the force (Motion).

You Can Find the Size of the Force Using F = BIl

The force acting on a conductor in a magnetic field depends on three things:

1) The magnetic flux density — how many field (flux) lines there are in a region. This shows the strength of the magnetic field (p.195).
2) The size of the current through the conductor.
3) The length of the conductor that's in the magnetic field.

When the current is at 90° to the magnetic field it is in, the force acting on it can be found using the equation on the right.

$$F = B \times I \times l$$

Force (N), Magnetic flux density (T, tesla or N/Am), Current (A), Length (m)

Left-hand rule for the motor effect — drive on the left...

Learn the left-hand rule and use it — don't be scared of looking like a muppet in the exam.

Q1 A 35 cm long piece of wire is at 90° to an external magnetic field. The wire experiences a force of 0.98 N when a current of 5.0 A is flowing through it. Calculate the magnetic flux density of the field. [2 marks]

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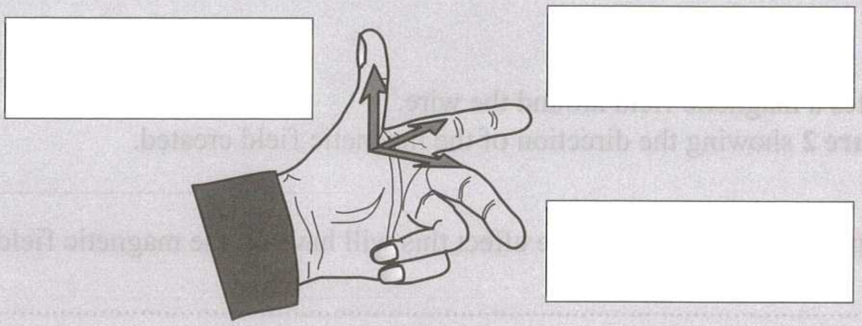
Warm-Up

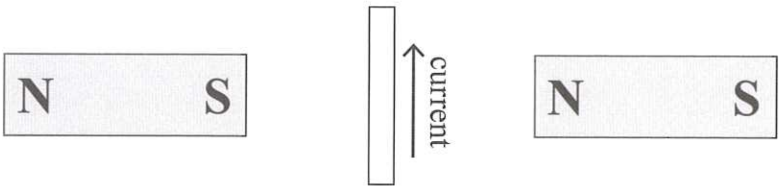
The diagram shows a left hand being used for Fleming's left hand rule.
Using **three** of the labels below, label the thumb and fingers in the diagram.



Force
Magnet
Magnetic field
Current
Voltage
Wire

1 A wire is placed between two magnets, as shown in **Figure 1**. A current is flowing through the wire, in the direction shown. Grade 4-6

Figure 1



a) What will happen to the wire?

- [ ] **A** It will move to the left.
- [ ] **B** It will move away from you, into the paper.
- [ ] **C** It will move towards you, out of the paper.
- [ ] **D** It will remain stationary.

[1]

b) This effect is called the motor effect. Explain the cause of the motor effect.

....

....

[2]

c) State **three** factors which determine the magnitude of the force acting on the wire.

1. ....

2. ....

3. ....

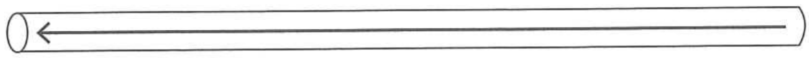
[3]

[Total 6 marks]

2 **Figure 2** shows a wire which has a current flowing through it.
The arrow shows the direction of the current.

Grade 4-6

Figure 2



a) The flow of charge creates a magnetic field around the wire.
Draw field lines on **Figure 2** showing the direction of the magnetic field created.

[2]

b) The direction of the current is reversed. State the effect this will have on the magnetic field.

....

....

[1]

c) Give **one** way to increase the strength of the magnetic field produced by the wire.

....

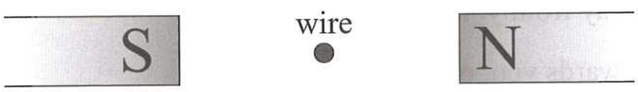
[1]

[Total 4 marks]

3 A 0.75 m section of wire, carrying a current of 0.4 A, is placed into a magnetic field, shown in **Figure 3**. When the wire is perpendicular to the field, it experiences a force of 1.2 N.

Grade 6-7

Figure 3



Calculate the magnetic flux density of the field. Give the correct unit in your answer.

Magnetic flux density = ...

Unit = ...

[Total 4 marks]

Exam Practice Tip

Don't get confused between which hand you're using for a situation. Use your right hand for finding the magnetic field produced by a current-carrying conductor and your left hand for the force acting on a wire in a magnetic field.