Fleming's left-hand rule

4.7.2.2 · Magnetism and electromagnetism · revision notes

When a wire carrying a current is in a magnetic field, the wire and the magnet exert a force on each other: the motor effect. You need to use Fleming's left-hand rule to find the direction of the force, recall what affects its size, and calculate it with F = B I l, which is given on the equation sheet. Higher tier only.

Key facts

- Motor effect: a wire carrying a current in a magnetic field has a force on it
- F in N, B in T (tesla), I in A, l in m
- Left hand: First finger = Field, seCond finger = Current, thuMb = Motion (force)
- Wire parallel to the field: no force
- $F = BIl$ for a wire at right angles to the field (given on the equation sheet)
- Force bigger for bigger B, bigger I or longer l
- Field goes N → S; conventional current goes + → −
- Reverse the current or the field: force reverses. Reverse both: no change

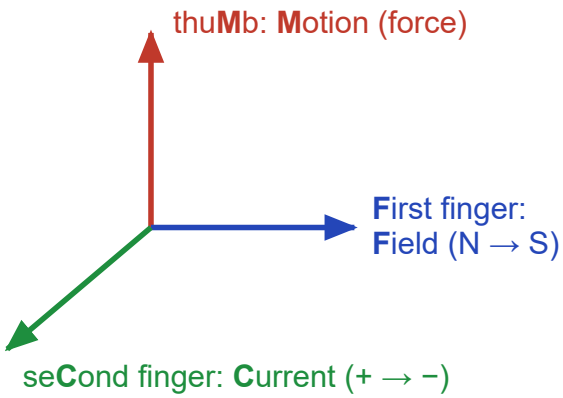
Notes

The motor effect

- When a wire carrying a current is placed in a magnetic field, the magnet and the wire **exert a force on each other**. This is the **motor effect**.
- It happens because the magnetic field of the current interacts with the magnetic field of the magnet.
- The force is biggest when the wire is at **right angles** to the field. If the wire is **parallel** to the field, there is no force.
- Reversing the current **or** reversing the field reverses the direction of the force. Reversing both leaves the direction unchanged.

Fleming's left-hand rule

- Hold the thumb, first finger and second finger of your **left** hand all at right angles to each other.
- **F**irst finger → **F**ield (from north to south).
- Se**c**ond finger → **C**urrent (conventional current, from + to −).
- Thu**m**b → **M**otion: the direction of the force on the wire.



Use your LEFT hand. The three directions are all at right angles.

- The rule shows that the force is at right angles to both the current and the field.

The size of the force

- The force is bigger if you increase the **magnetic flux density** (the strength of the field), the **current**, or the **length** of wire in the field.
- For a wire at right angles to the field, force = magnetic flux density × current × length: $F = BIl$
- F = force (N), B = magnetic flux density (tesla, T), I = current (A), l = length of wire in the field (m).
- Rearranged: $B = \frac{F}{Il}$, $I = \frac{F}{Bl}$, $l = \frac{F}{BI}$ Grade 7+ only
- Only the length of wire **inside** the field counts.
- Convert first: cm → m (÷ 100), mm → m (÷ 1000), mT → T (÷ 1000), mA → A (÷ 1000), mN → N (÷ 1000), μT → T (÷ 1 000 000).

How to answer each type of question

Calculate the force using F = B I l

2 to 3 marks | Grade 6

1. Write down F = B I l from the equation sheet.
2. Convert the length to metres (and mT to T, mA to A).
3. Substitute and work out the answer.
4. Give the unit: newtons (N).

Example. A 6.0 cm length of wire is at right angles to a uniform magnetic field of flux density 0.25 T. The current in the wire is 3.2 A.
Calculate the force on the wire. [3 marks]

Model answer.

l = 6.0 cm = 0.060 m	(1)
F = 0.25 × 3.2 × 0.060	(1)
F = 0.048 N	(1)

Rearrange F = B I l to find B, I or l

3 to 4 marks | Grade 7

1. Convert all values to N, A, m and T first.
2. Substitute into F = B I l before rearranging: this can earn a mark even if you slip later.
3. Divide to find the unknown.
4. Give the unit if asked (tesla, T, for magnetic flux density).

Example. A wire carries a current of 1.5 A. A 40 mm length of the wire is at right angles to a magnetic field. The force on the wire is 4.8×10^{-3} N.
Calculate the magnetic flux density of the field. Give the unit. [4 marks]

Model answer.

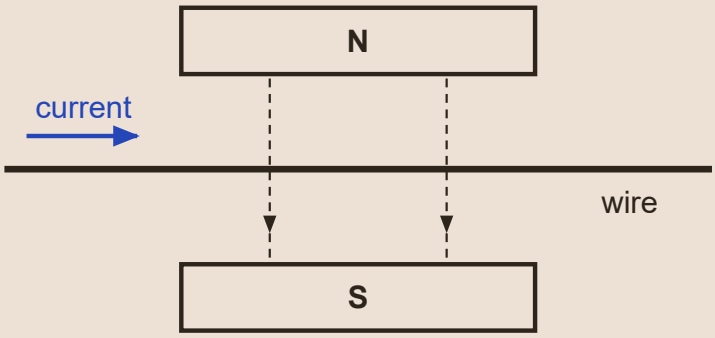
l = 40 mm = 0.040 m	(1)
$4.8 \times 10^{-3} = B \times 1.5 \times 0.040$	(1)
$B = 4.8 \times 10^{-3} \div 0.060 = 0.080$	(1)
tesla / T	(1)

Use Fleming's left-hand rule to find a direction

1 to 3 marks | **Grade 5**

1. Point your first finger from N to S (the field).
2. Turn your hand until your second finger points along the current (+ to −).
3. Your thumb now shows the direction of the force.
4. To reverse the force, reverse the current or the field (not both).

Example. A horizontal wire runs across the page from left to right, between the poles of a magnet. The north pole is above the wire and the south pole is below it. The current in the wire is from left to right.



(a) Use Fleming's left-hand rule to find the direction of the force on the wire. [1 mark]
(b) State two different changes, each of which would reverse the direction of the force. [2 marks]

Model answer.

(a) Into the page (1)

(b) Reverse the direction of the current (1). Reverse the magnetic field / swap the poles of the magnet (1).

Explain why a wire in a magnetic field moves

2 to 4 marks **Grade 5**

1. Say the current produces a magnetic field around the wire.
2. Say this field interacts with the field of the magnet, giving a force (the motor effect).
3. For 'give ways to increase the force', choose from: bigger current, stronger magnet, longer length of wire in the field.

Example. A short copper rod rests across two horizontal metal rails between the poles of a magnet. When there is a current in the rod, the rod rolls along the rails.
(a) Explain why the rod moves. [2 marks]
(b) Give two ways of making the force on the rod bigger. [2 marks]

Model answer.

(a) The current in the rod produces a magnetic field around it (1). This interacts with the field of the magnet, so there is a force on the rod (the motor effect) (1).

(b) Any two, 1 mark each: increase the current; use a stronger magnet (greater magnetic flux density); make a longer length of the rod lie in the field.

Don't lose marks

- Using the length in cm or mm instead of metres.
- Using the right hand, or swapping the field and current fingers.
- Taking the current from − to +: use conventional current, + to −.
- Pointing the field finger from S to N: the field goes from N to S.
- Using the whole length of the wire instead of only the length inside the field.
- Forgetting the unit tesla (T) when asked for a magnetic flux density.

More tips

Memory tricks

- Fleming's LEFT hand for Motors: in the UK, motor cars drive on the left.
- The left-hand rule in order: thuMb = Motion, First finger = Field, seCond finger = Current.
- Quick check: the force is always at right angles to both the wire and the field. If your answer is along the wire or along the field lines, start again.
- Read $F = BIl$ as 'F equals Bil' to remember the order.

Exam technique

- Write the equation, then the substitution with converted units, then the answer with its unit: each step can earn a mark.
- Use your left hand in the exam: turn your hand, not the paper, until the first two fingers match the diagram.
- For 'factors that affect the size of the force', name all three: magnetic flux density (or 'a stronger magnet'), current and length. 'Bigger magnet' is not the same as 'stronger magnet'.
- F = BIl can be joined to other ideas: on a graph of force against current the gradient is Bl, and the force can go into F = ma to find an acceleration.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4 — **State what the motor effect is**
A wire carrying a current in a magnetic field has a force on it, and so does the magnet.

Grade 5 — **Recall the factors that affect the force**
The force is bigger for a stronger field (greater magnetic flux density), a bigger current and a longer length of wire in the field.

Grade 5 — **Use Fleming's left-hand rule to find direction**
First finger = field (N to S), second finger = current (+ to −), thumb = force (motion).

Grade 5 — **Explain why a current-carrying wire moves**
The magnetic field of the current interacts with the field of the magnet, producing a force on the wire.

Grade 6 — **Calculate the force with F = BIl**
Substitute B in tesla, I in amperes and l in metres to get F in newtons.

Grade 7 — **Rearrange F = BIl after converting units**
e.g. find B in tesla when the length is given in mm or cm.

Grade 8 — **Predict how changes affect the force**
e.g. reversing both the current and the field leaves the direction unchanged; doubling I and halving l leaves F unchanged.

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