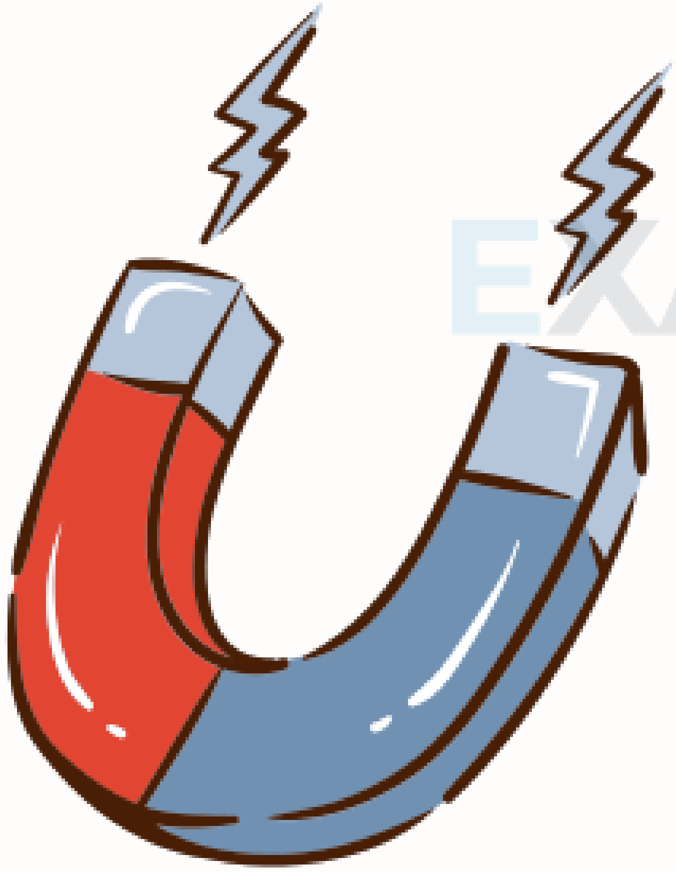
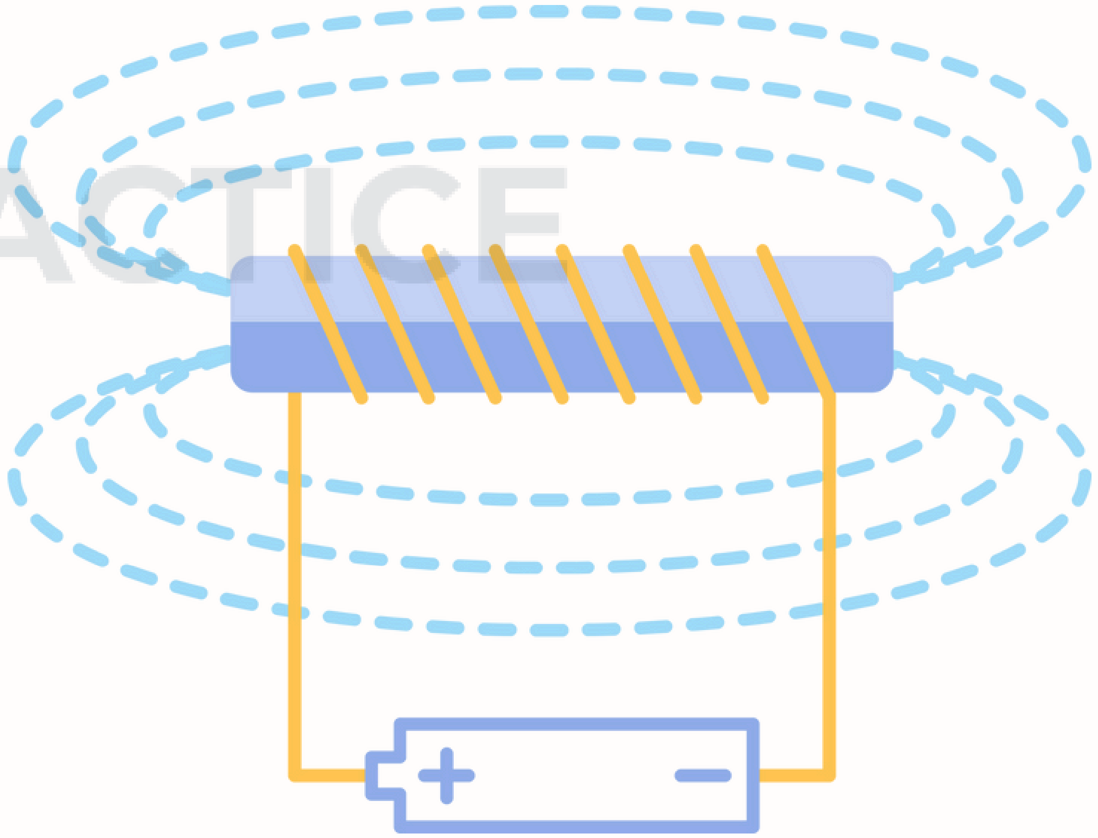
CIE IGCSE PHYSICS for board 0625 and 0972

(For exam 2025+)

C2

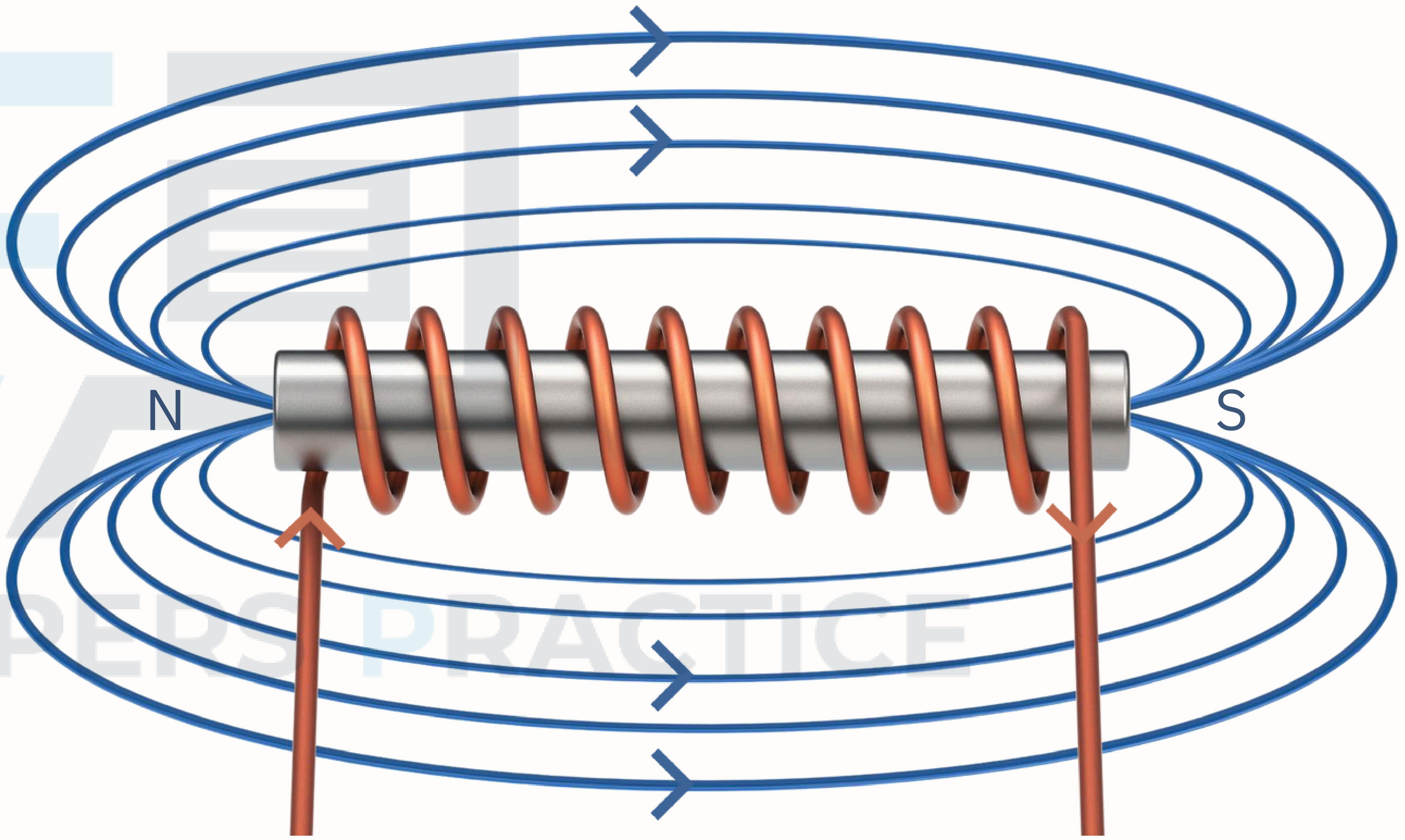
E0lectromagnetic Force





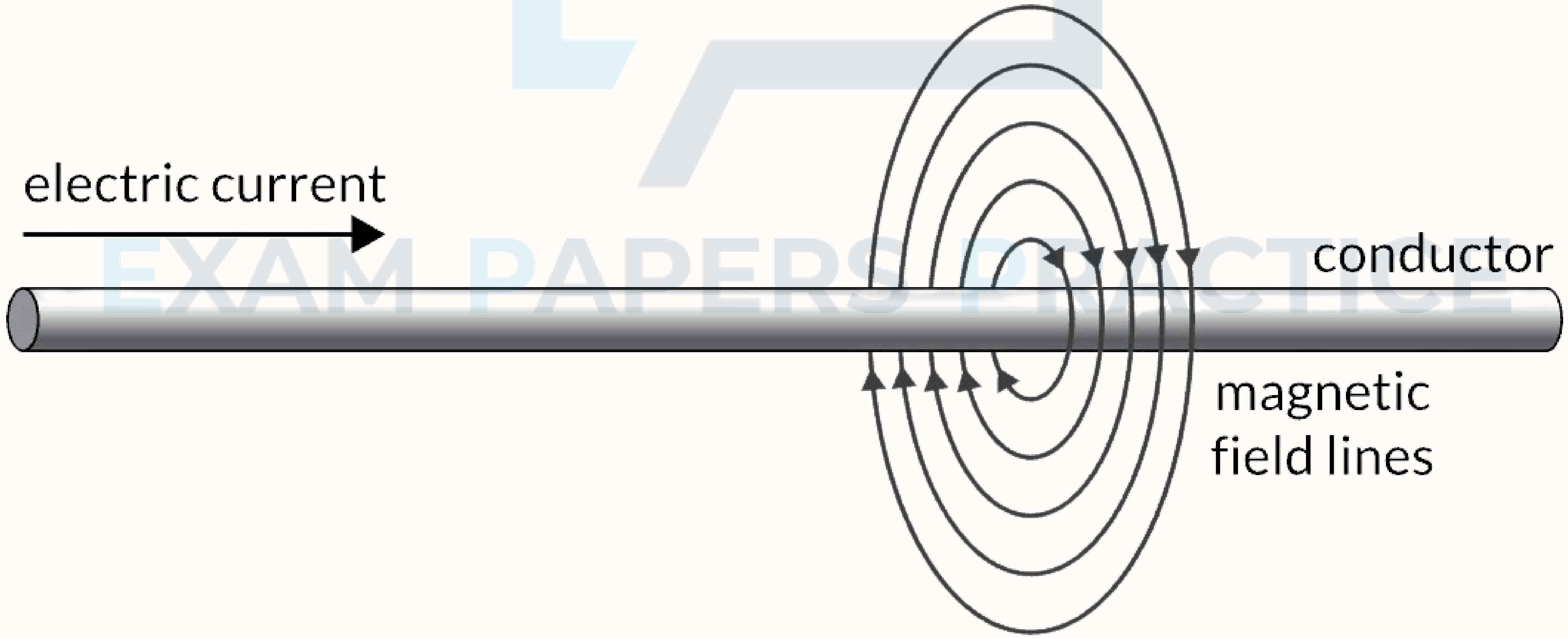
20.1 The magnetic effect of current

In chapter 16, we learned that the flow of current results in a magnetic field around the solenoid.

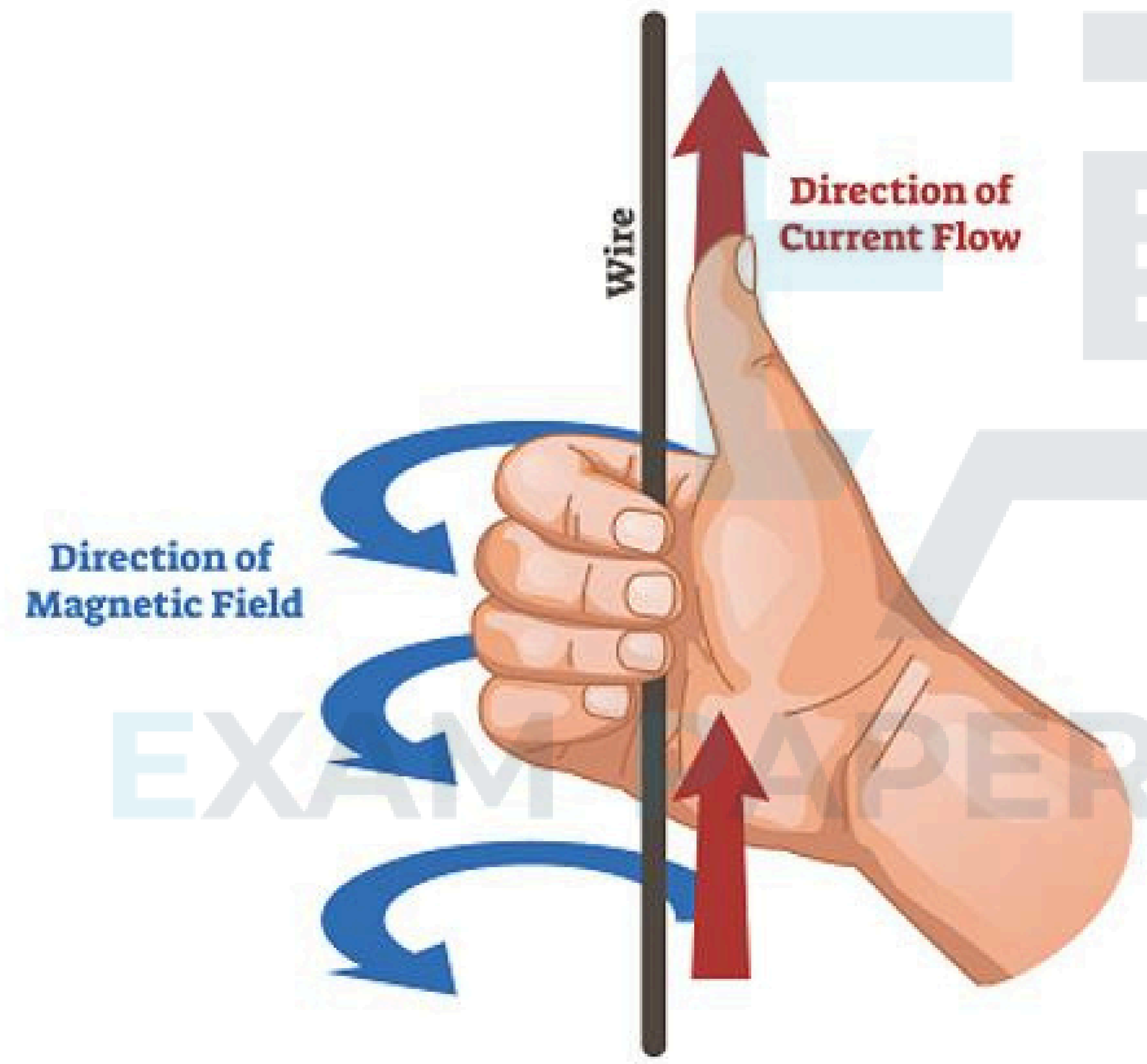


20.1 The magnetic effect of current

If you uncoil a solenoid, it becomes a straight wire. When current flows through this wire, it generates a magnetic field around it.
Winding the wire into a coil is a way of concentrating the magnetic field.



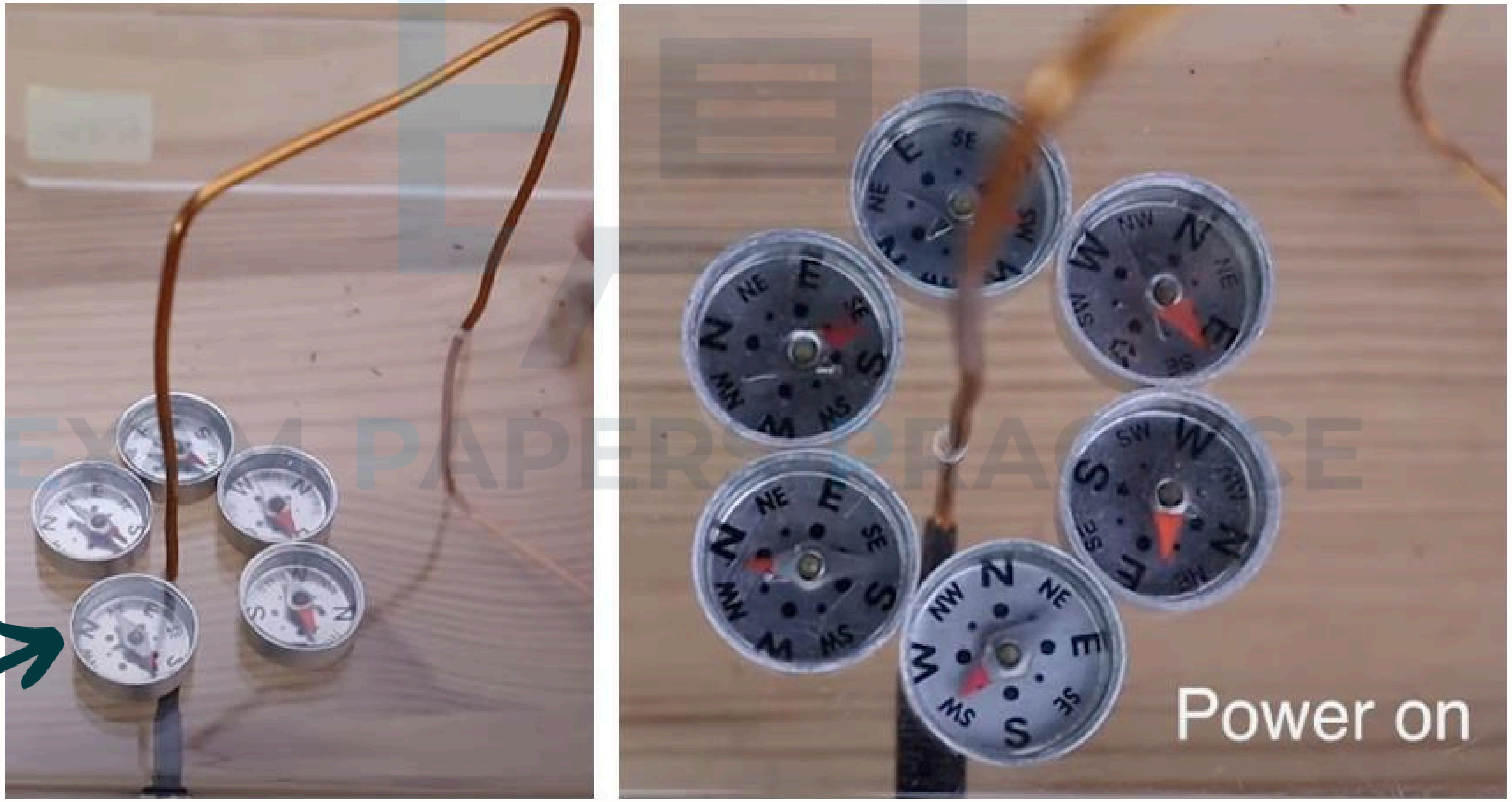
20.1 The magnetic effect of current



The right-hand grip rule helps determine the direction of the magnetic field around a current-carrying conductor, where the thumb points in the direction of the currentand the curled fingers indicate the direction of the magnetic field lines.

20.1 The magnetic effect of current

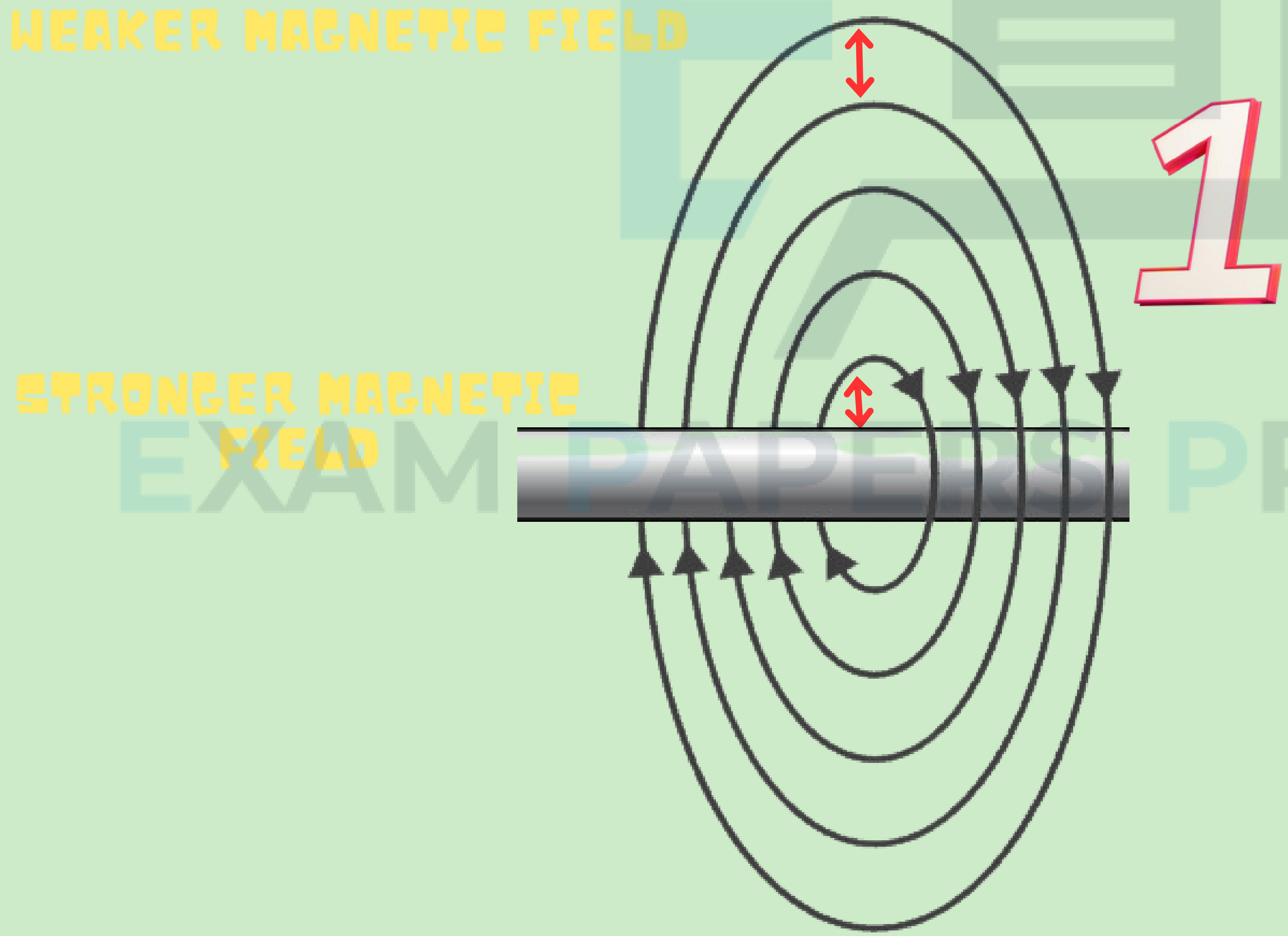
Experiment to investigate the field around a straight wire carrying current



Plotting compass

20.1 The magnetic effect of current

Characteristics of the magnetic field produced by the current in the wire

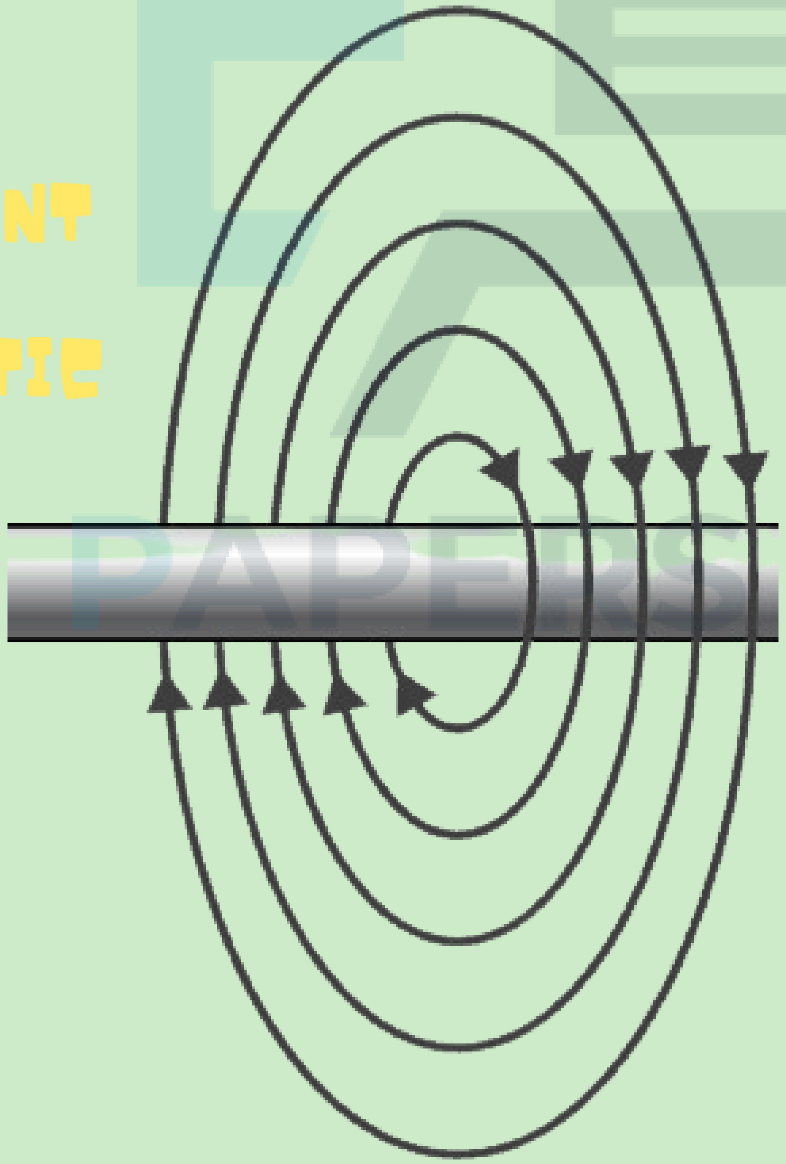


Further from the wire, the circular field lines are spaced farther apart, indicating a weaker magnetic field.

20.1 The magnetic effect of current

Characteristics of the magnetic field produced by the current in the wire

STRONGER CURRENT
=
STRONGER MAGNETIC FIELD



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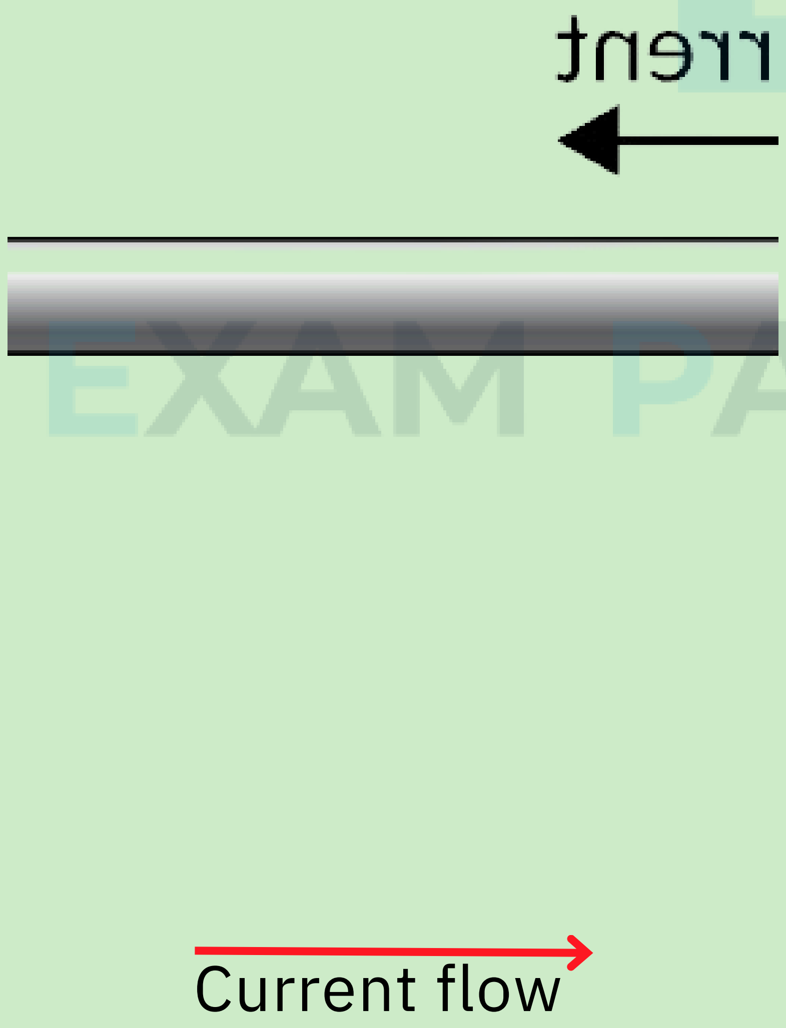
If the current increases, the magnetic field strengthens, causing the field lines to be closer together.

20.1 The magnetic effect of current

Characteristics of the magnetic field produced by the current in the wire



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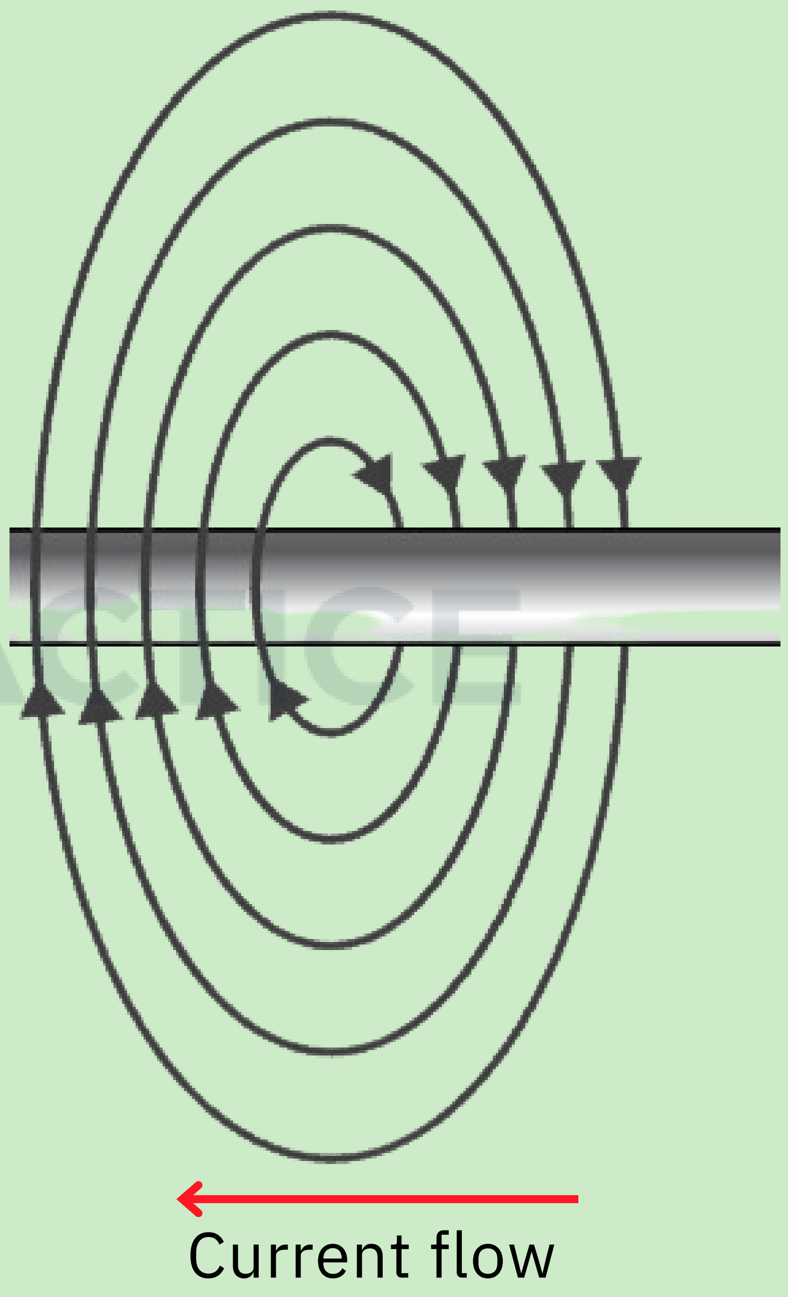
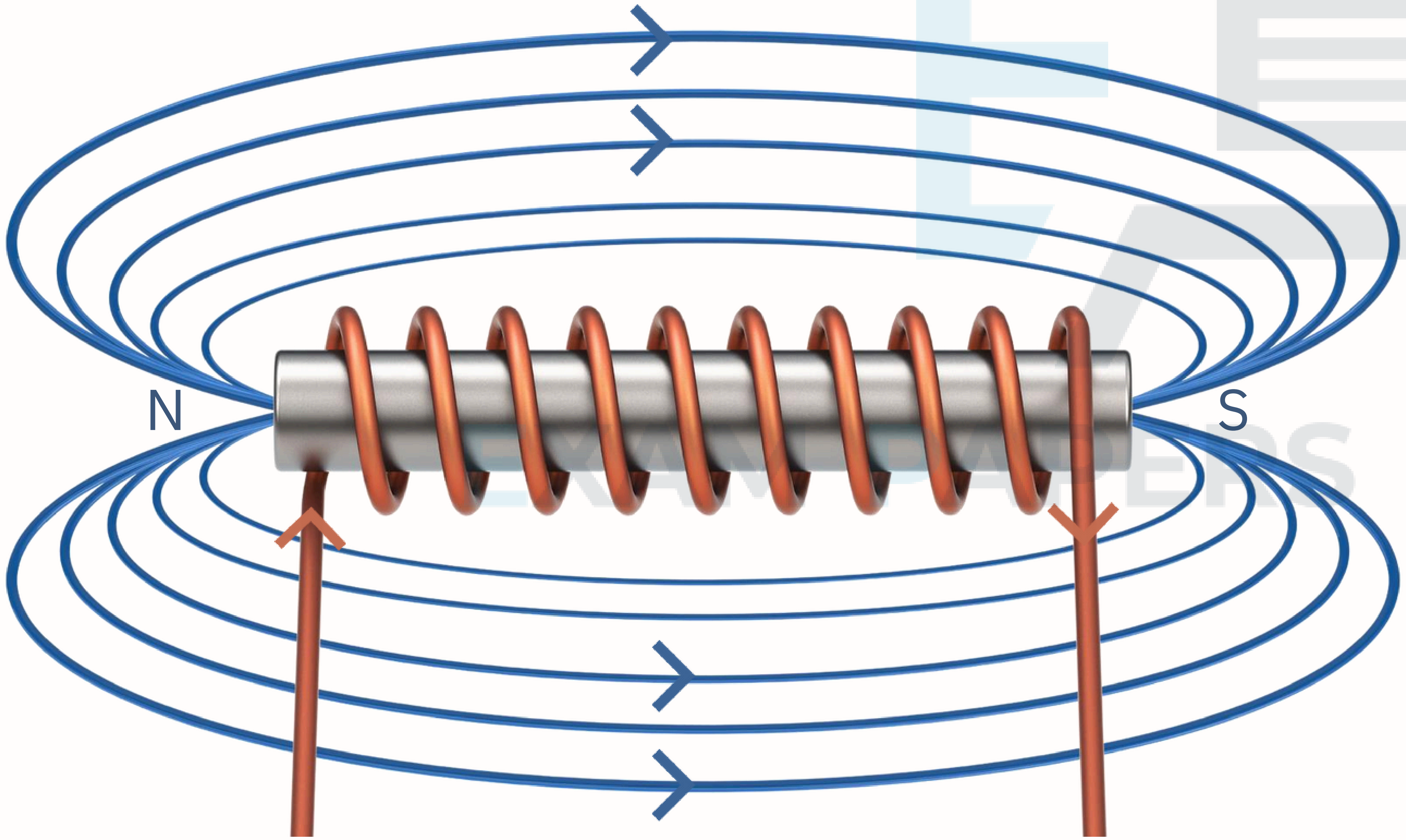
When the current's direction is reversed, the direction of the magnetic field lines also reverses.



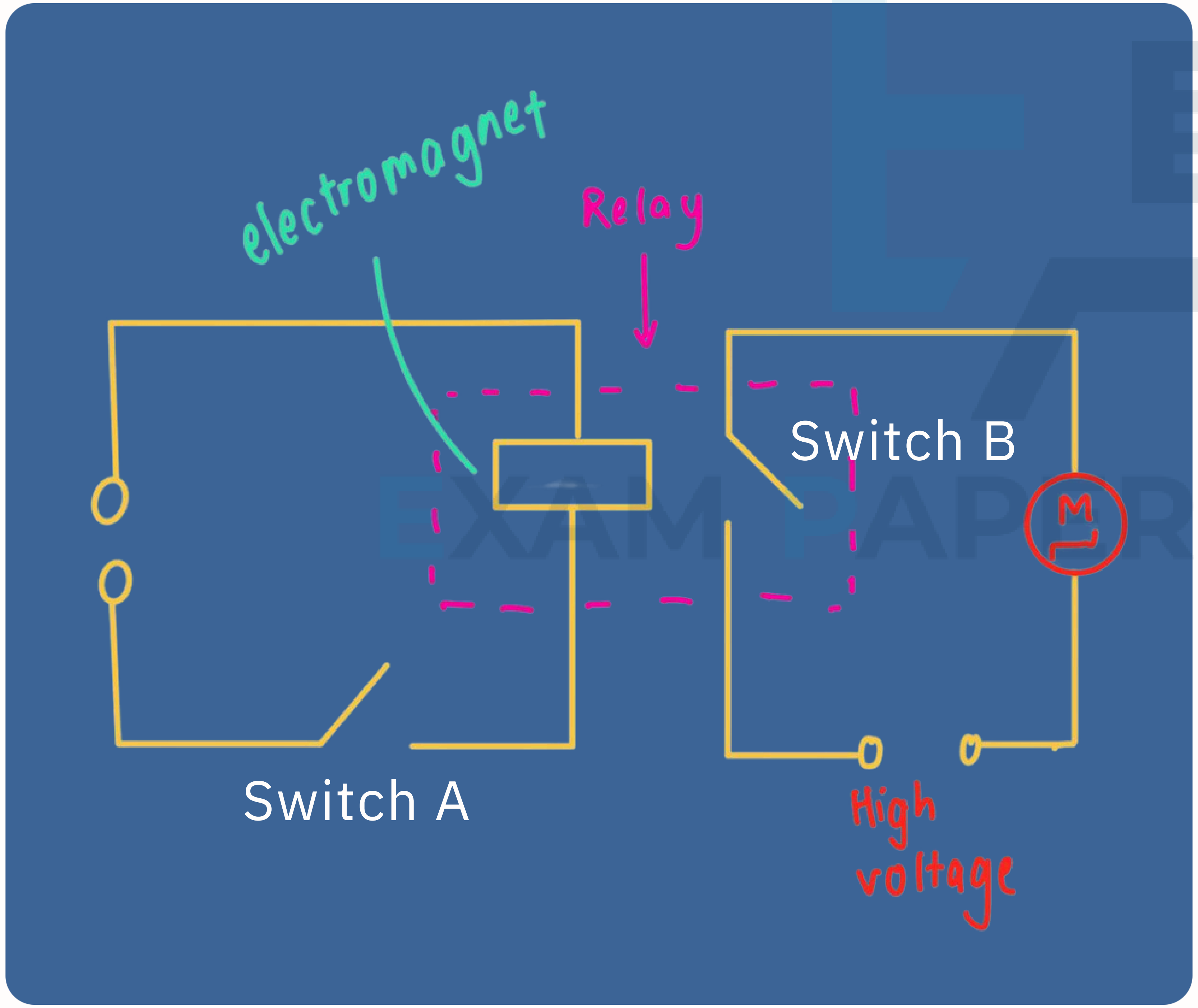
Characteristics of the magnetic field produced by the Solenoid



- The field lines are densely packed at the poles of the electromagnet.
- Inside the coil, the field lines are parallel, indicating a uniform magnetic field.
- The polarity of the electromagnet reverses when the direction of the current is reversed.

Application of an electromagnet - Relay

Characteristics of the magnetic field produced by the Solenoid



When switch A is closed, a small current flows through the coil of the electromagnet.

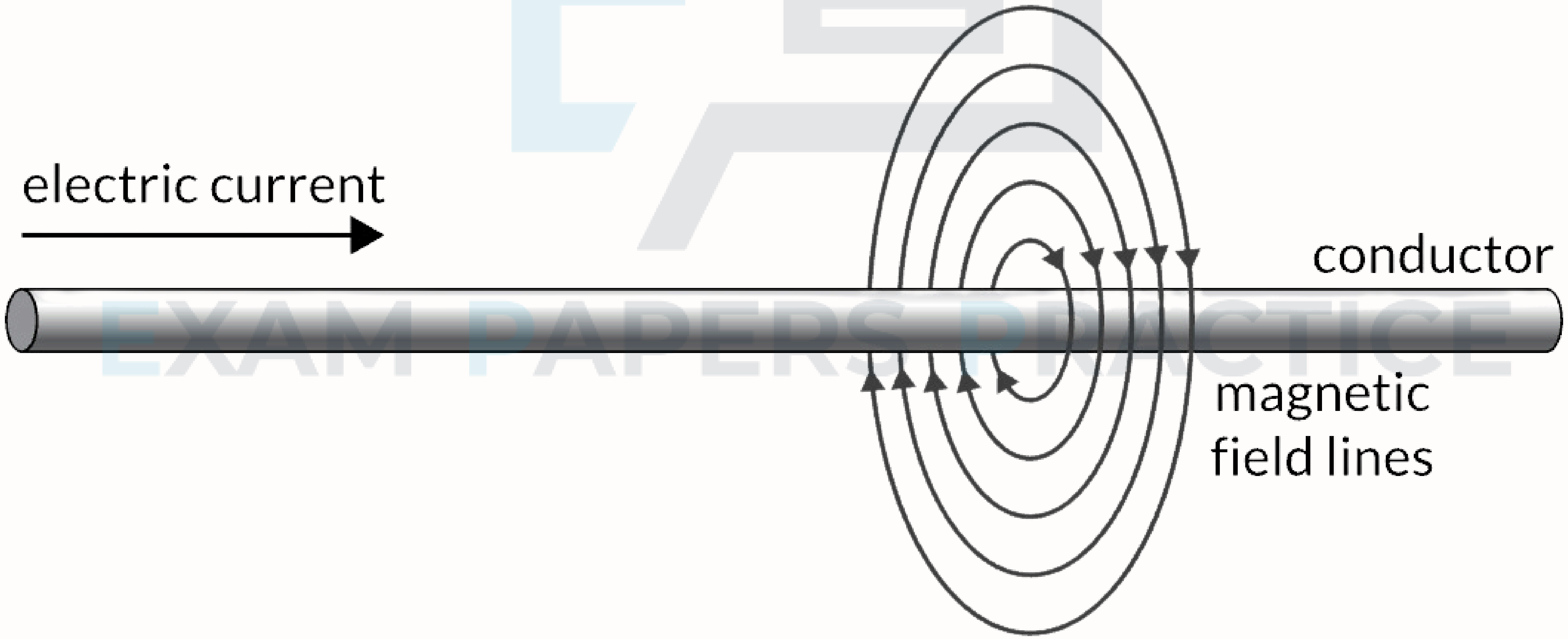
The electromagnet attracts the iron armature. As the armature moves, it pushes the two contacts at B together, thereby completing the second circuit.

Note that there is no electrical connection between the two circuits.

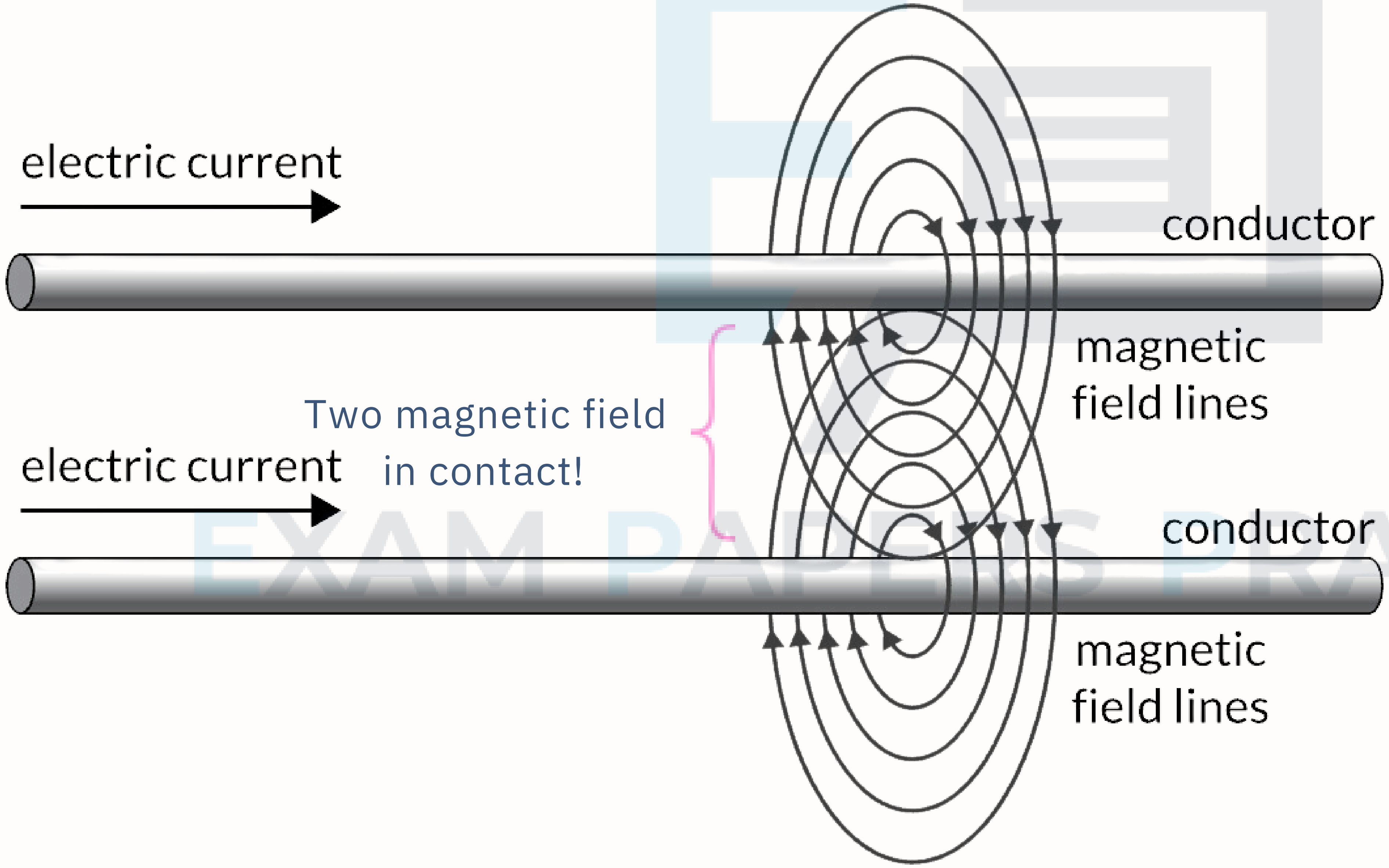
A relay is used to make a small current switch a larger current on and off.

20.2 Force on a current carrying conductor

We know that there is a magnetic field around an electric current.

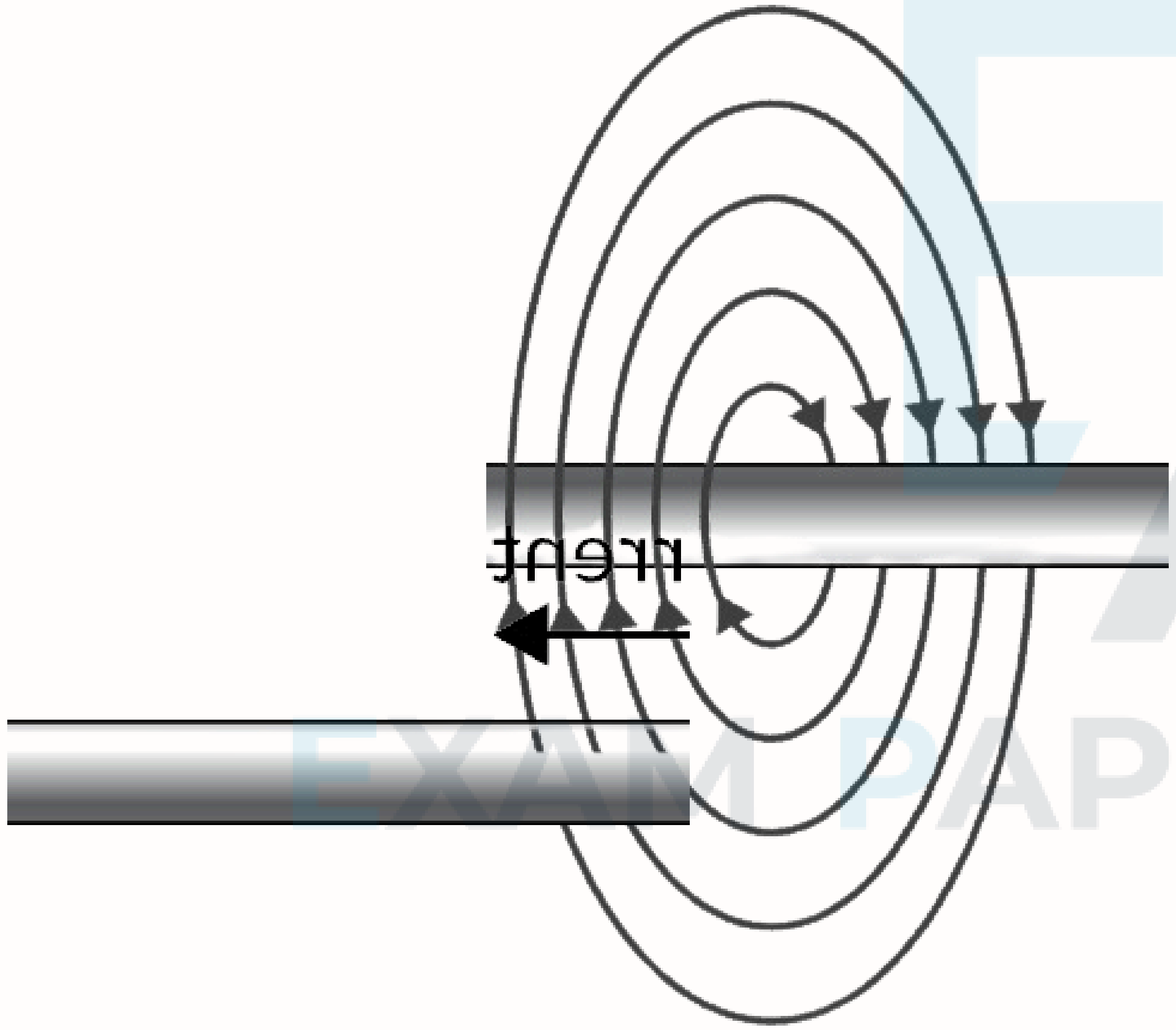


20.2 Force on a current carrying conductor



The magnetic field can be attracted or repelled by another magnetic field to produce movement. This is called the motor effect.

20.2 Force on a current carrying conductor



Current flow

Current flow

Definition of Motor Effect

The motor effect is the phenomenon where a current-carrying conductor experiences a force when placed in a magnetic field, causing it to move.

20.2 Force on a current carrying conductor

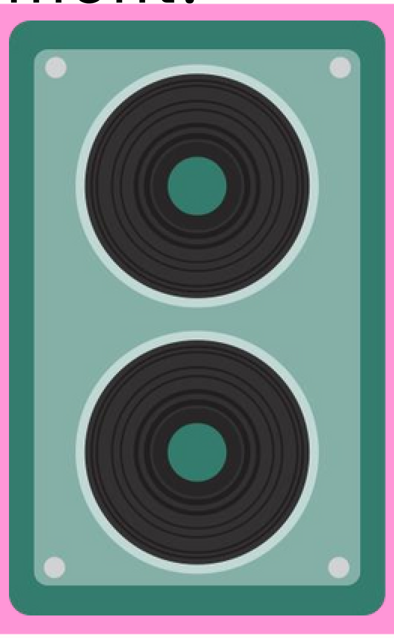
How does an electric motor work?

An electric motor consists of a coil with a current flowing through it within a magnetic field.

It doesn't necessarily have to be a coil; as long as current flows to intersect the magnetic field lines, it works.

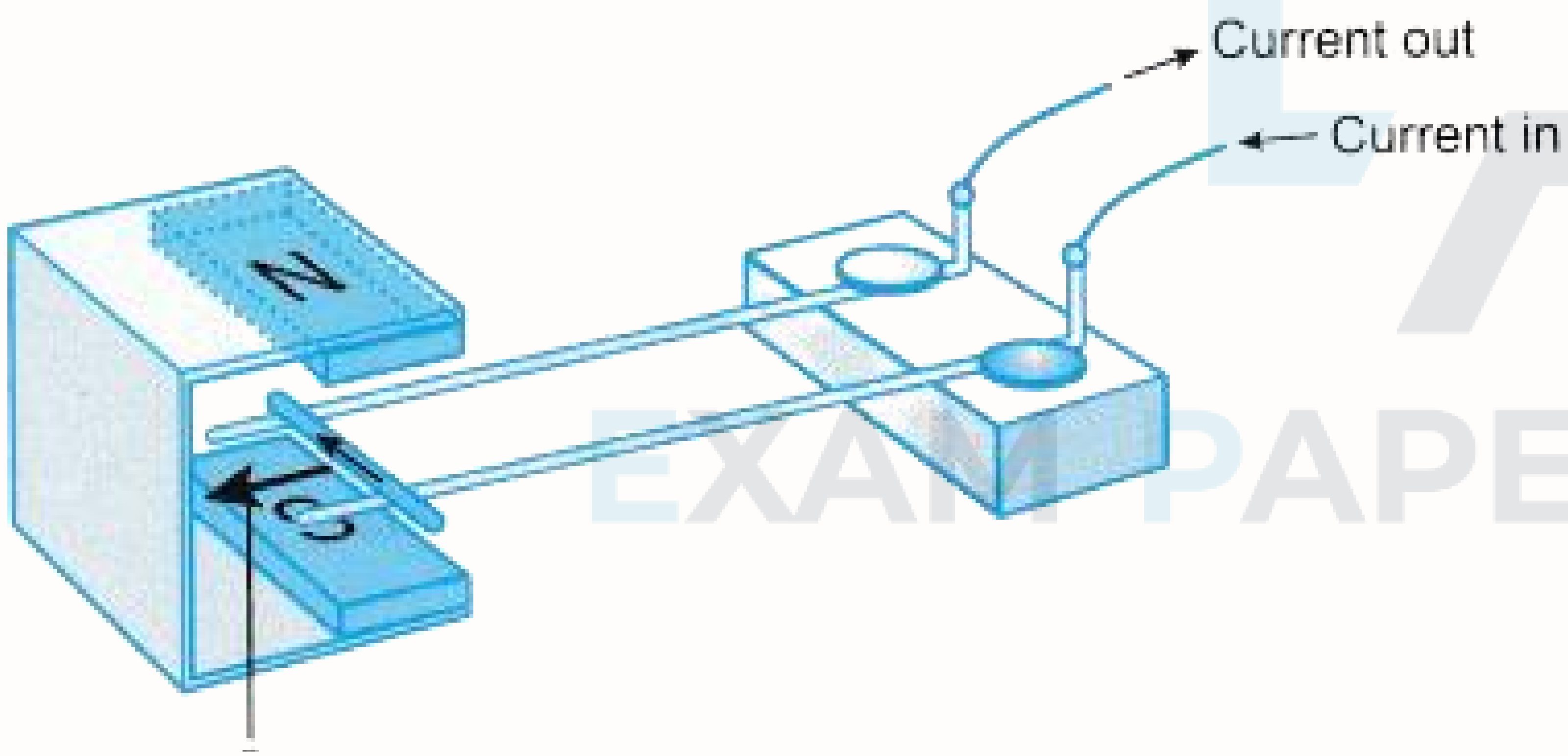
The motor rotates because the interaction between the magnetic fields generates a force that causes movement.

Example of application: Loudspeaker

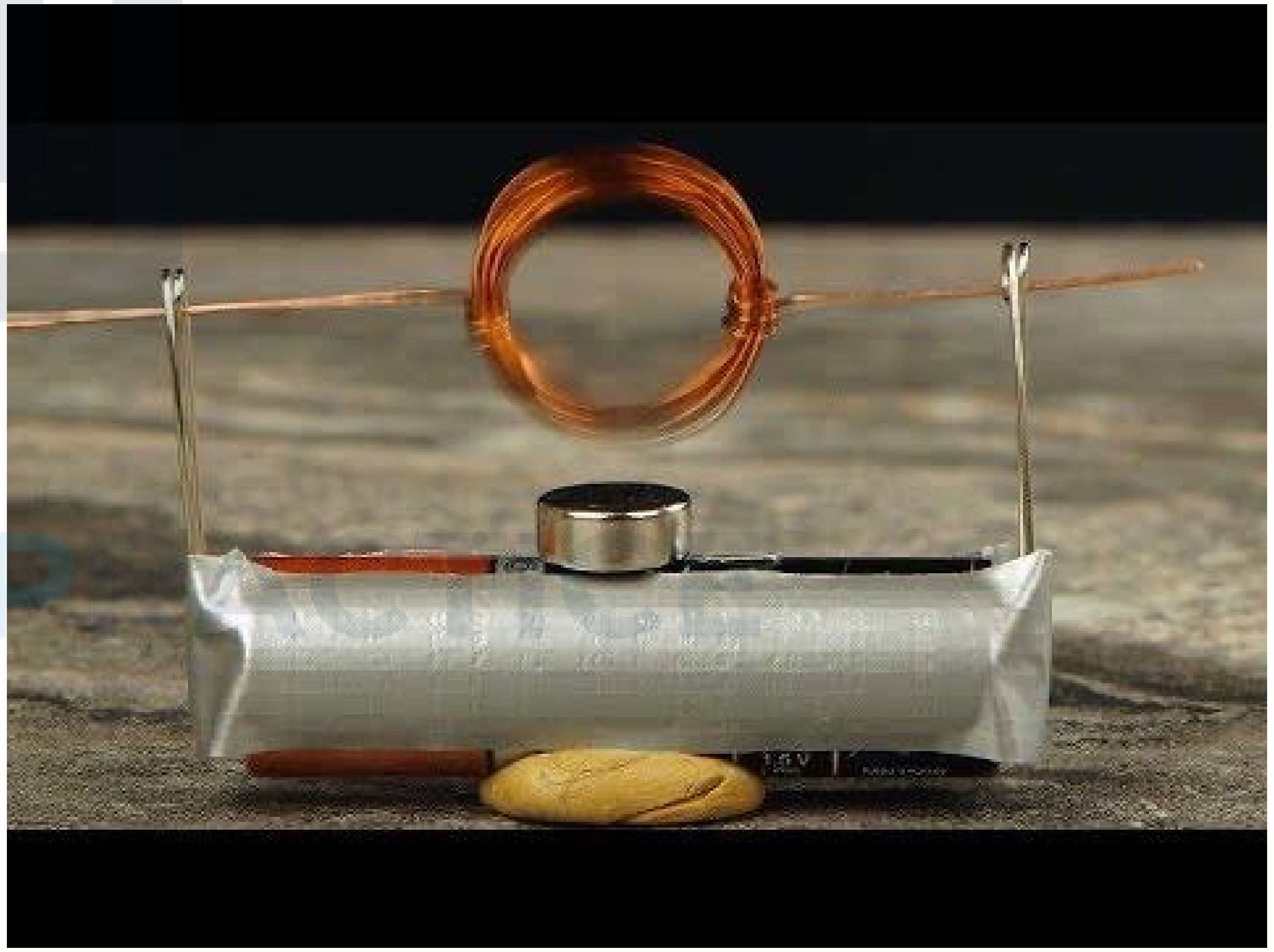


20.2 Force on a current carrying conductor

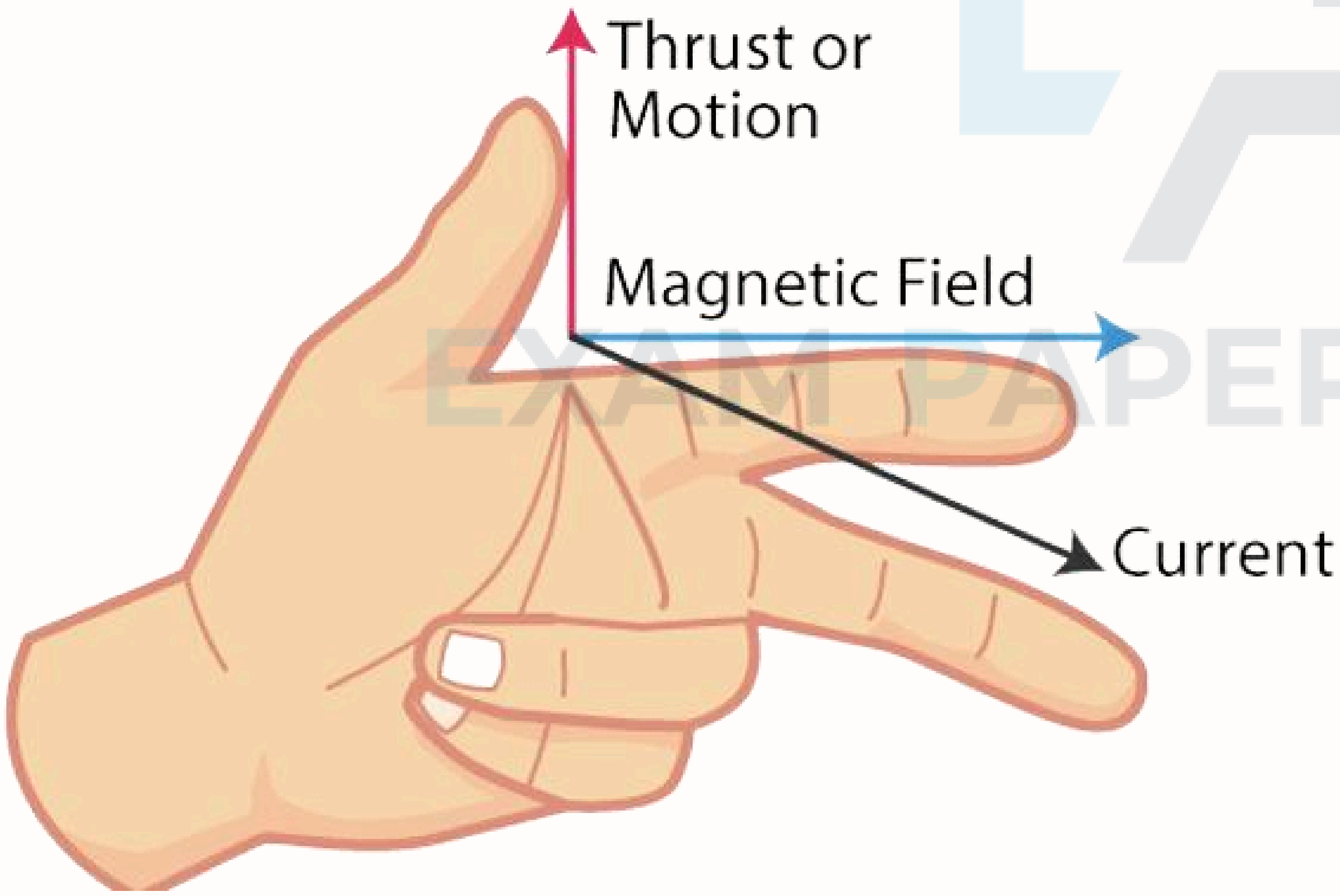
Experiment 1: Catapult field



Experiment 2: Rotating coil

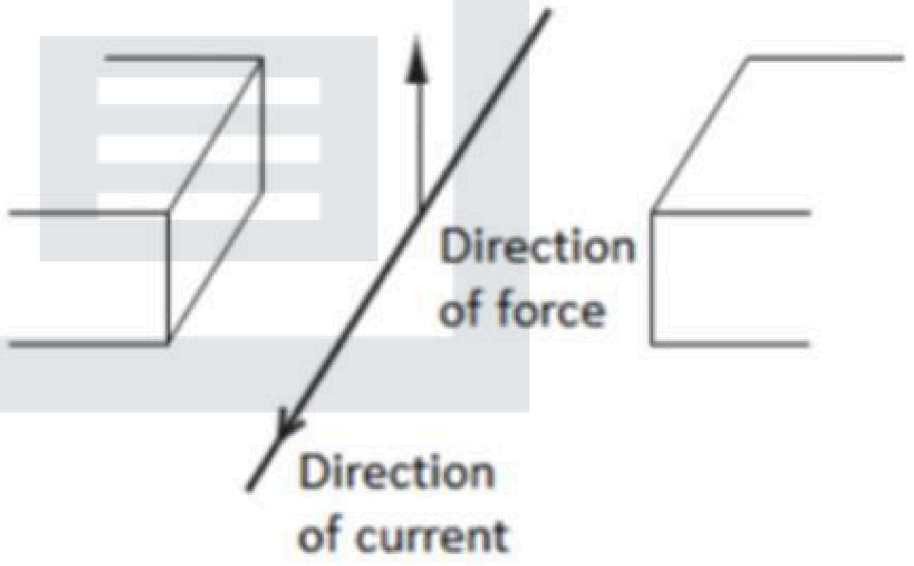


FLEMING'S LEFT HAND RULE



Fleming's left-hand rule is a mnemonic used to predict the direction of the force experienced by a current-carrying conductor in a magnetic field, where the thumb represents the direction of the force, the first finger indicates the direction of the magnetic field, and the second finger shows the direction of the current.

A current-carrying wire is placed between two magnetic poles as shown in the diagram below. It experiences an upwards force.



What is the orientation of the magnetic poles?

	left magnet	right magnet
A	N	N
B	S	N
C	N	S
D	S	S

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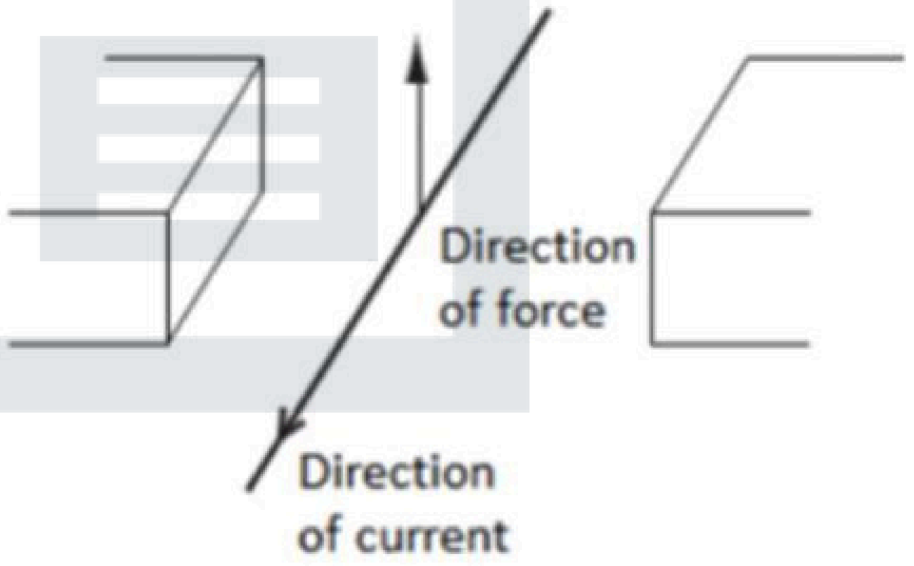

What is the orientation of the magnetic poles?

	left magnet	right magnet
A	N	N
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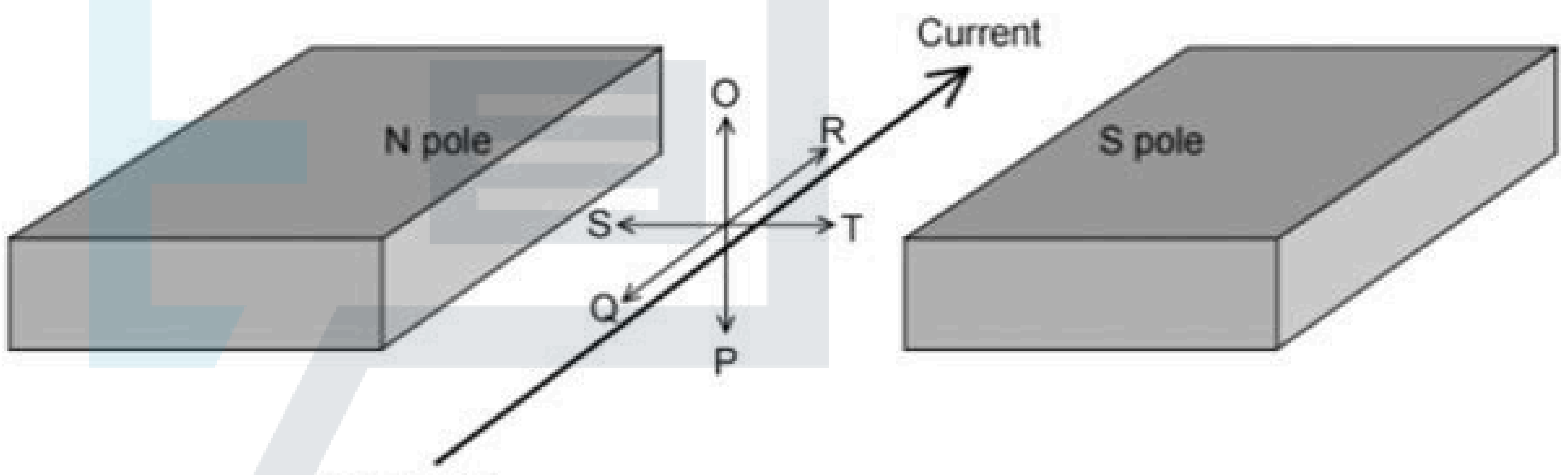
A current-carrying wire is placed into a magnetic field as shown in the diagram. The wire experiences a force.



In which direction is the force?

A OP

B PO

C ST

D QR

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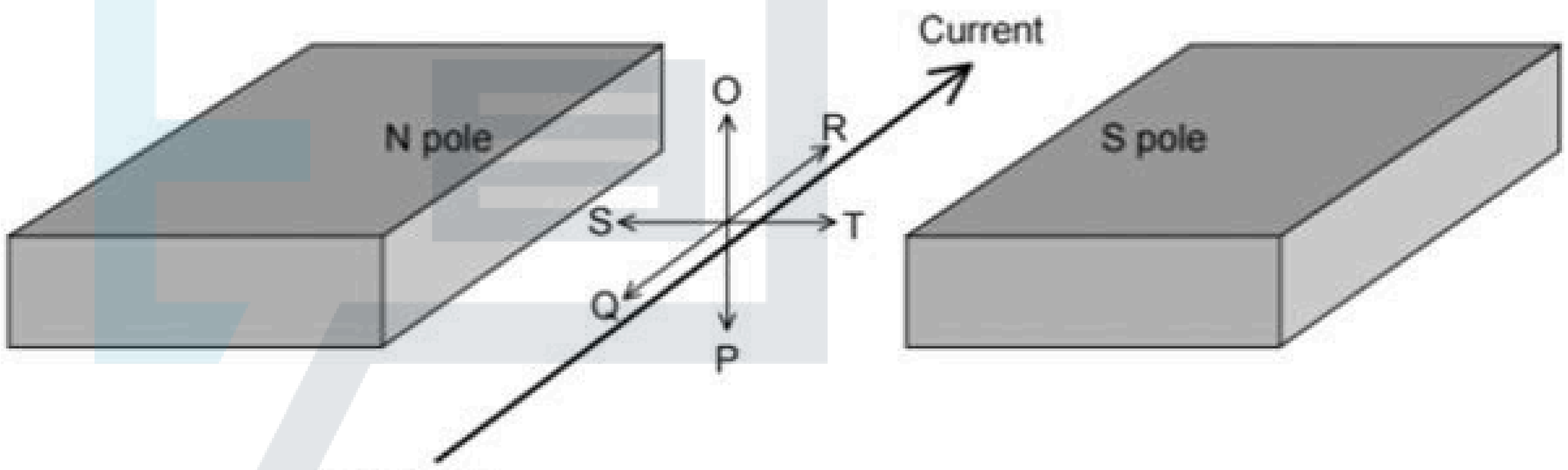

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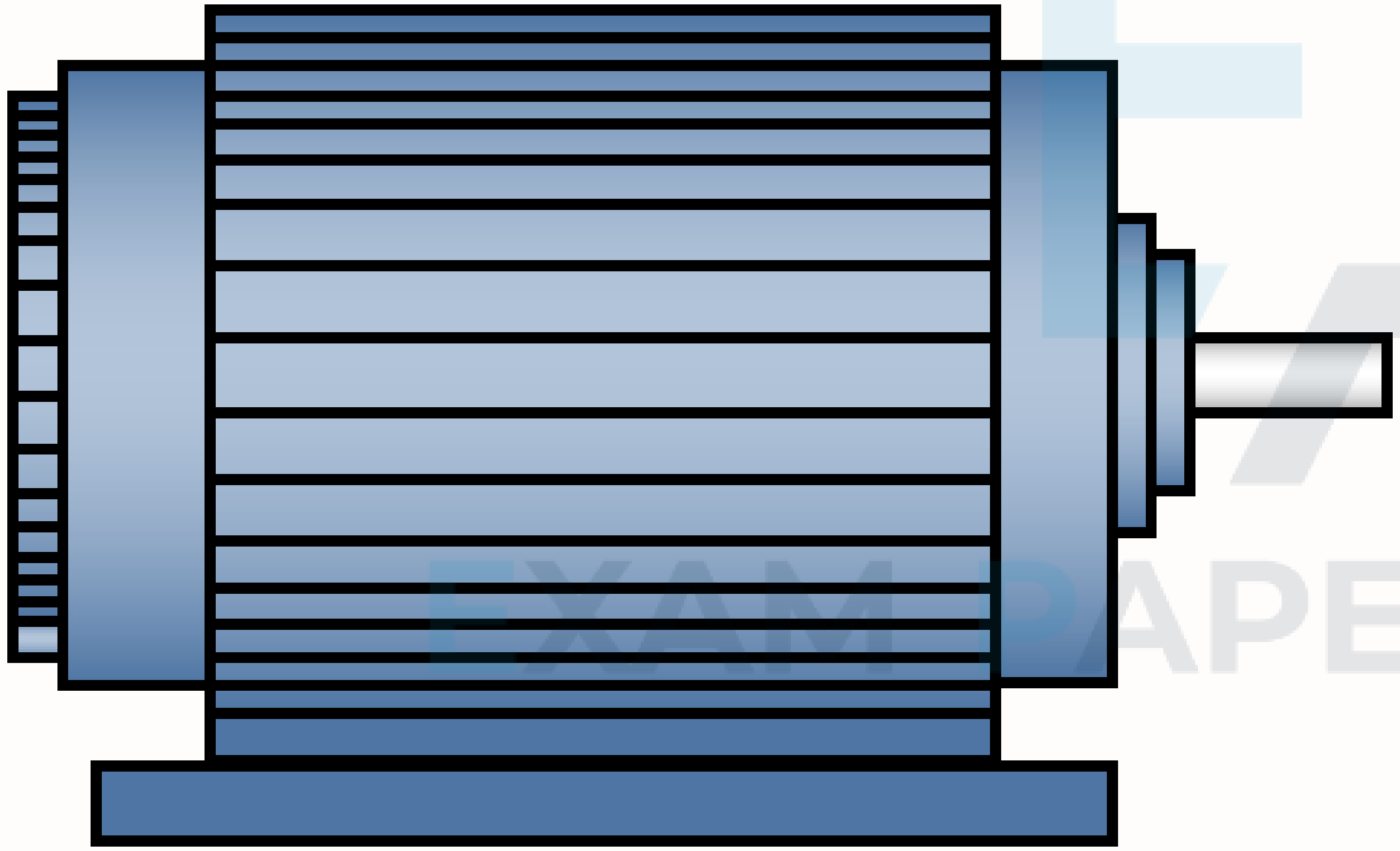
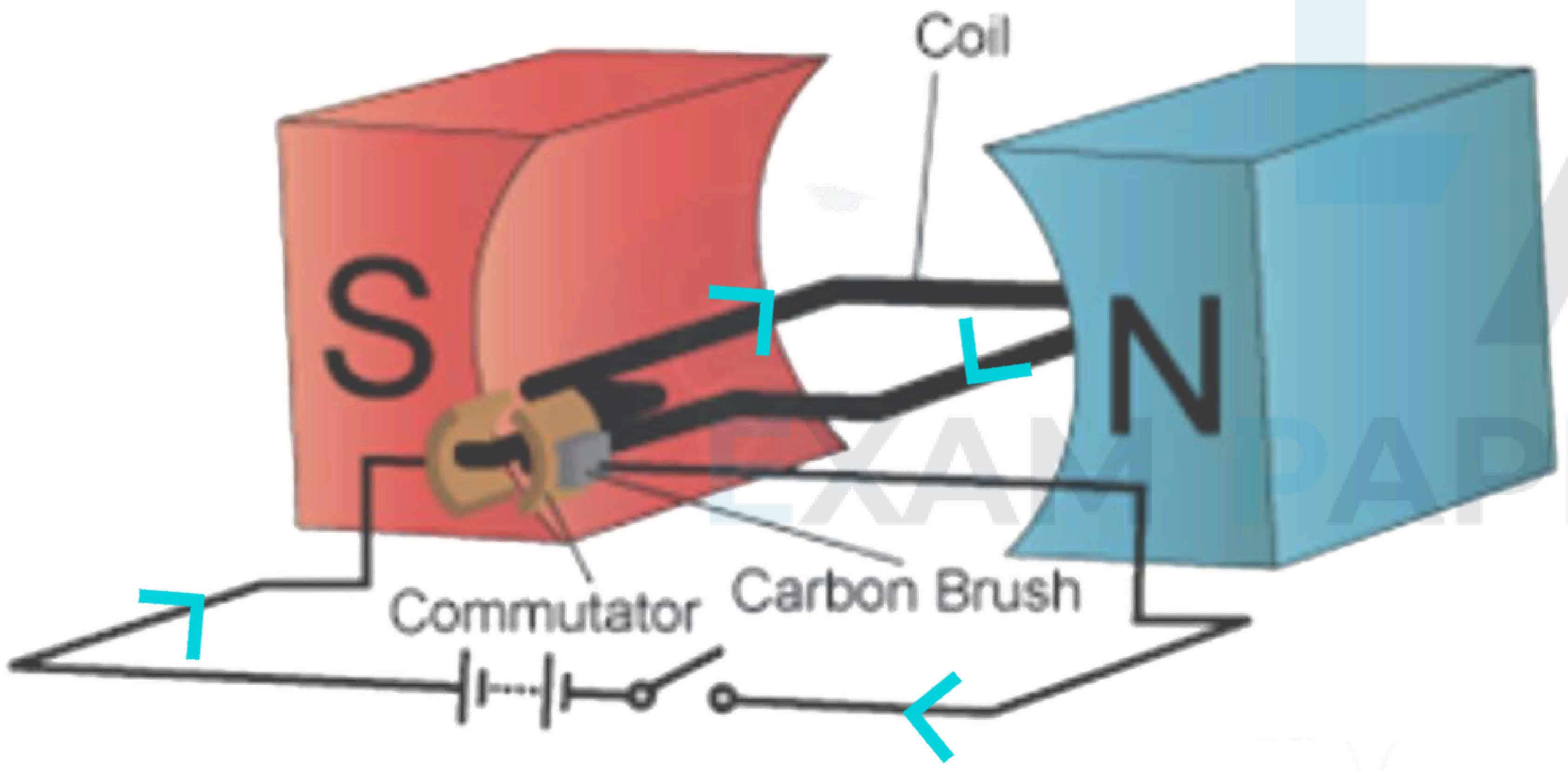
20.3 Electric Motor



The movement produced in the motor effect experiment (Catapult field) is not very practical. The conductor moves out of the field, and the effect ceases.

A motor is specifically engineered to harness the motor effect to generate turning effect.

20.3 Electric Motor



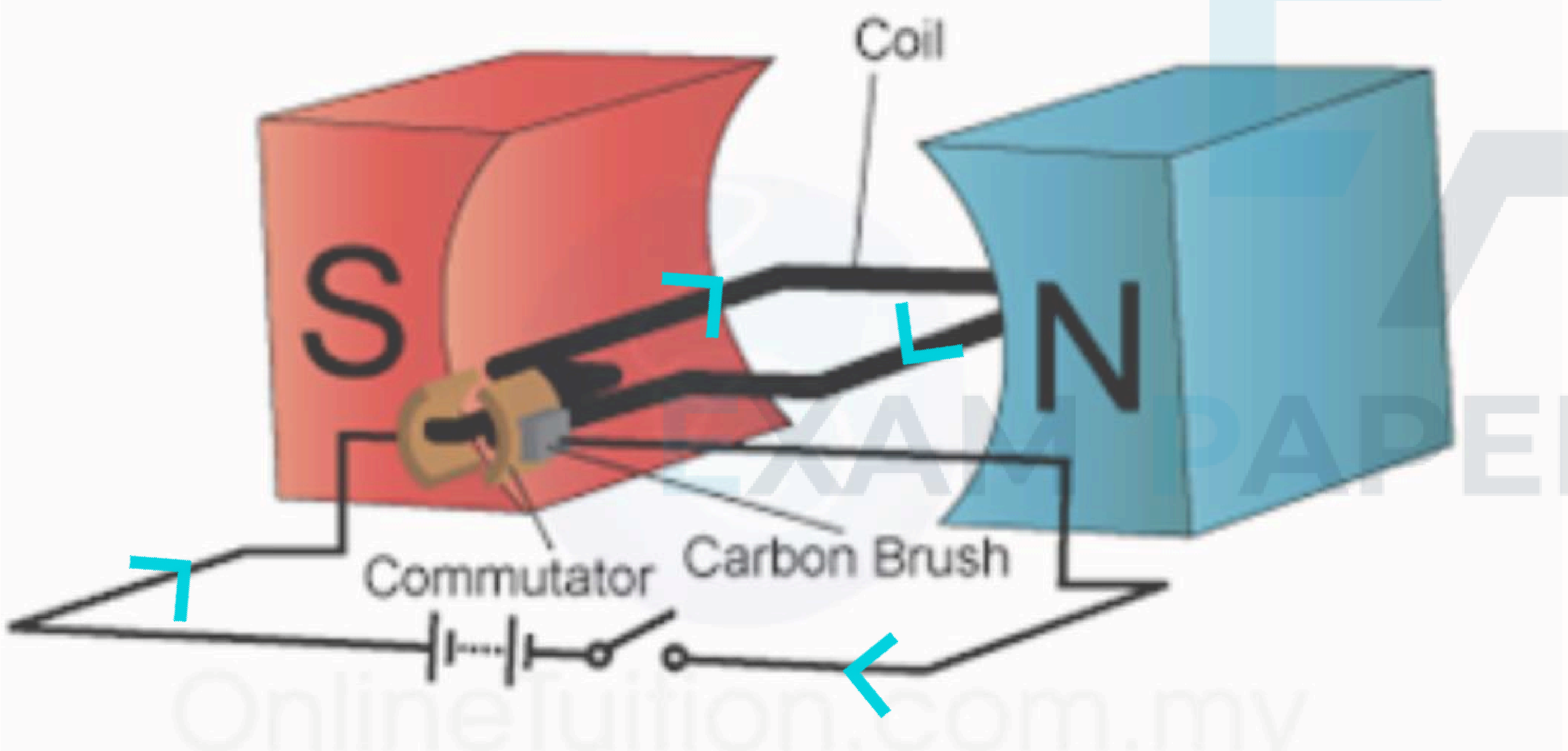
How is turning effects produced?

Only the two longer sides of the coil experience a force.

Using Fleming's left hand rule:
Force on the left side will be upward.
Force on the right side will be downward

This creates a turning effect, causing clockwise rotation in our case.

20.3 Electric Motor



Continued...

When the coil is in a vertical position, there is no turning effect. Momentum from the coil's rotation carries it further around.

As the coil's momentum carries it around, wires AB and CD exchange positions.

Consequently, current always enters from the right and flows counterclockwise around the coil, ensuring the motor continues to rotate in the same direction.

20.3 Electric Motor

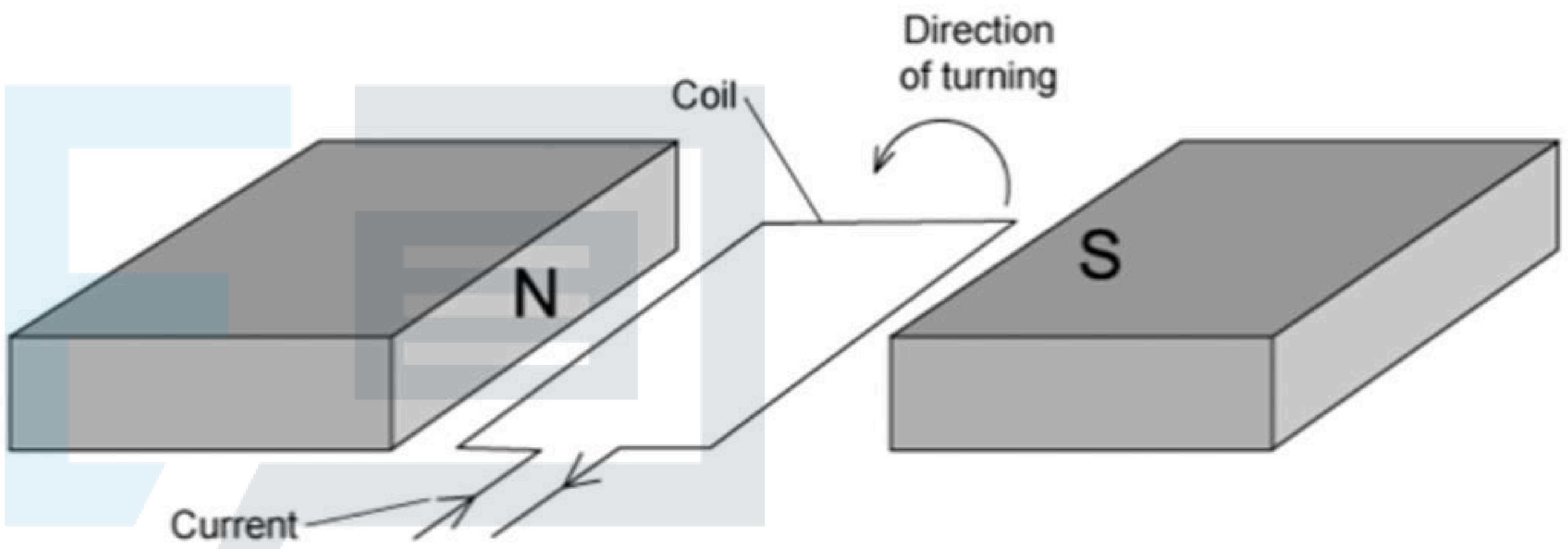
3 ways to improve the turning effects

Increase the current

Increase the strength of the magnetic field

Increase the number of turns of wire in the coil

A simple DC electric motor is shown in the diagram.



Which of the following changes would make the coil turn more quickly?

A Reducing the strength of the magnetic field.

B Reversing the direction of the current AND swapping the magnetic poles

C Swapping the magnetic poles.

D Increasing the current in the coil.

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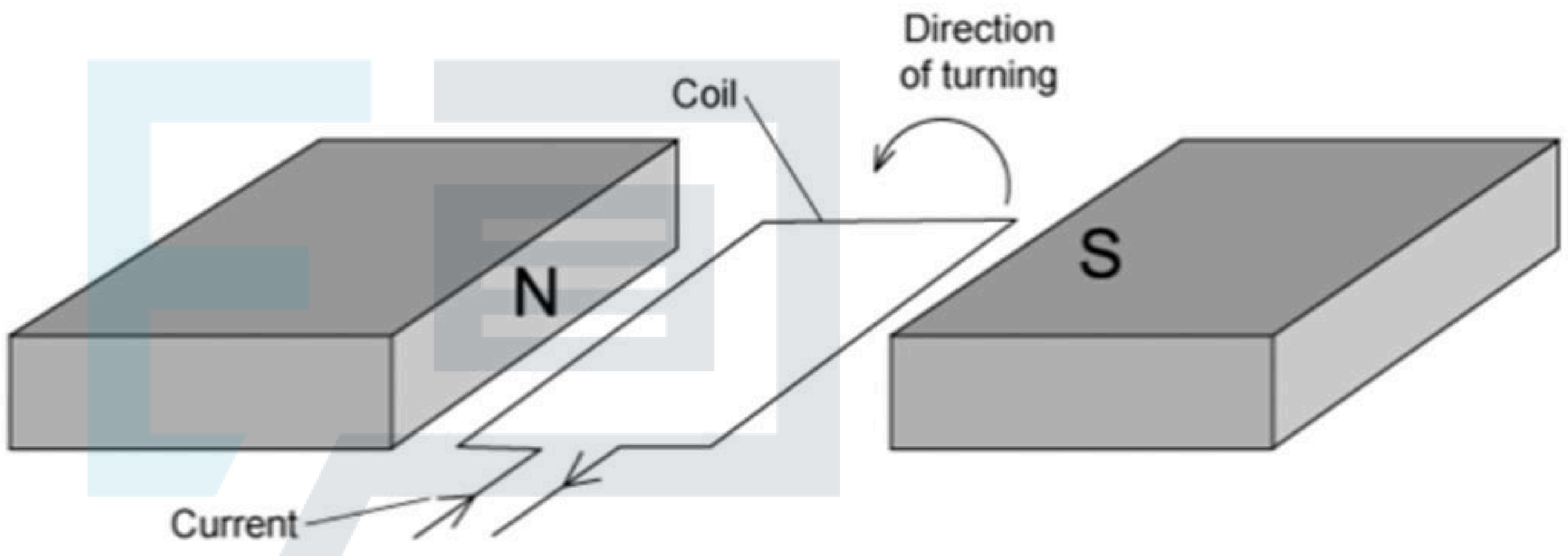

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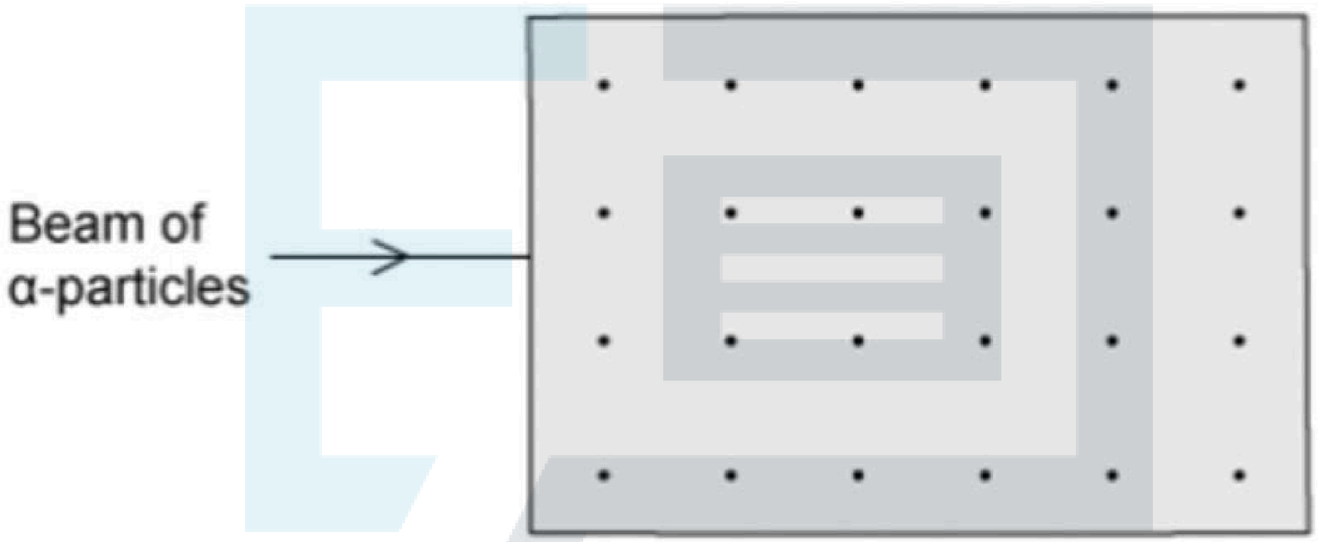
A magnetic field can be represented by the diagram shown below. The dots represent magnetic field lines coming out of the page:



A beam of alpha particles is directed through the field as shown above. Alpha particles, being charged, will be deflected by the field. In which direction will they be deflected?

A Upwards

B Downwards

C Into the page

D Out of the page

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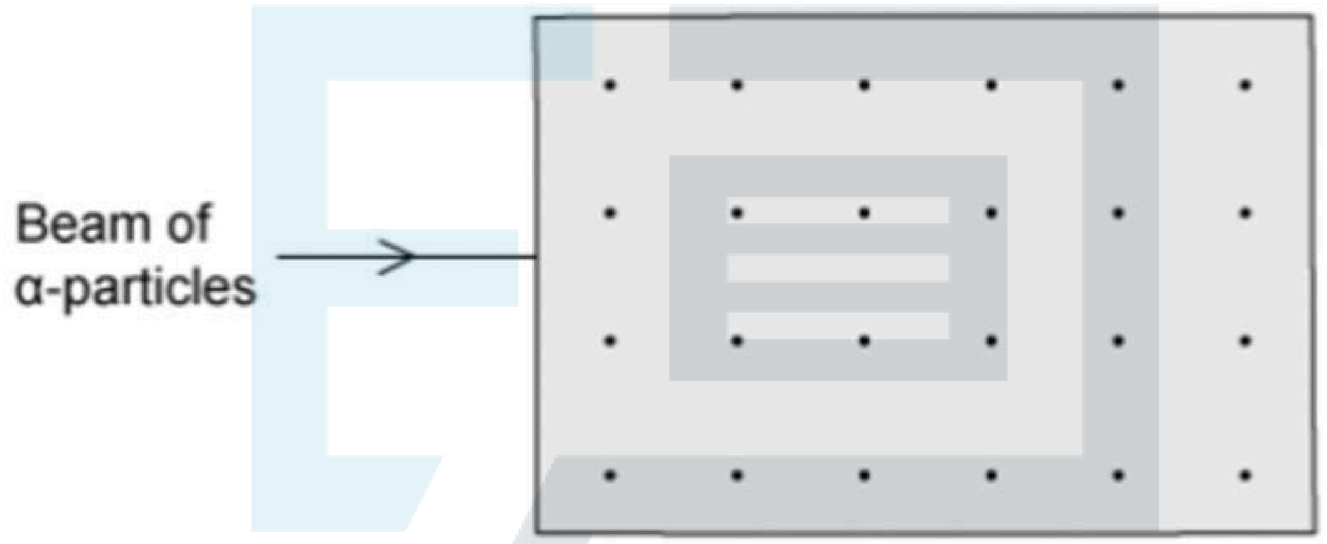

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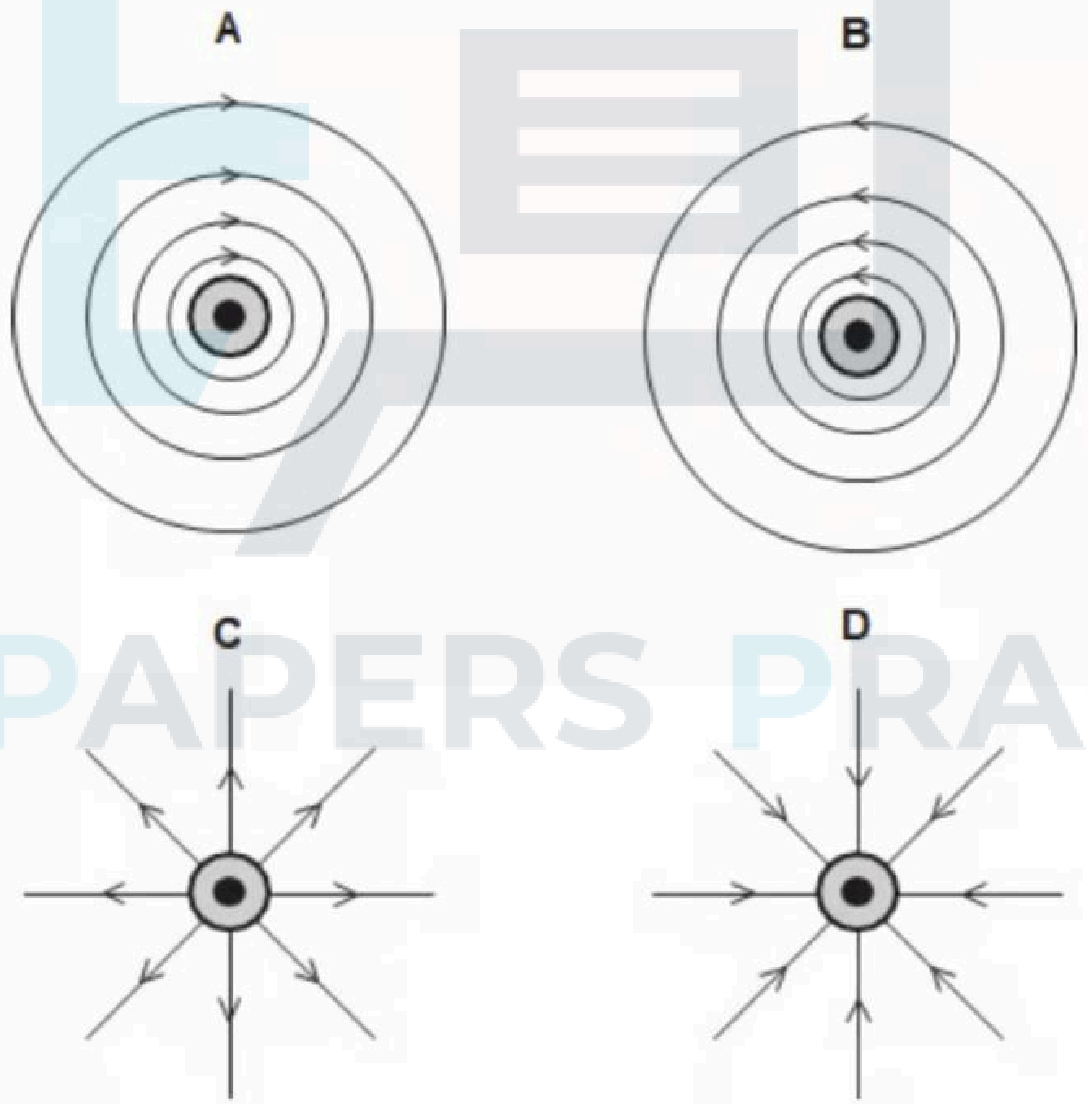
Four students are asked to draw the magnetic field pattern of a current-carrying wire. The wire is carrying the current out of the page.

The diagrams they draw are shown below.



Which is correct?

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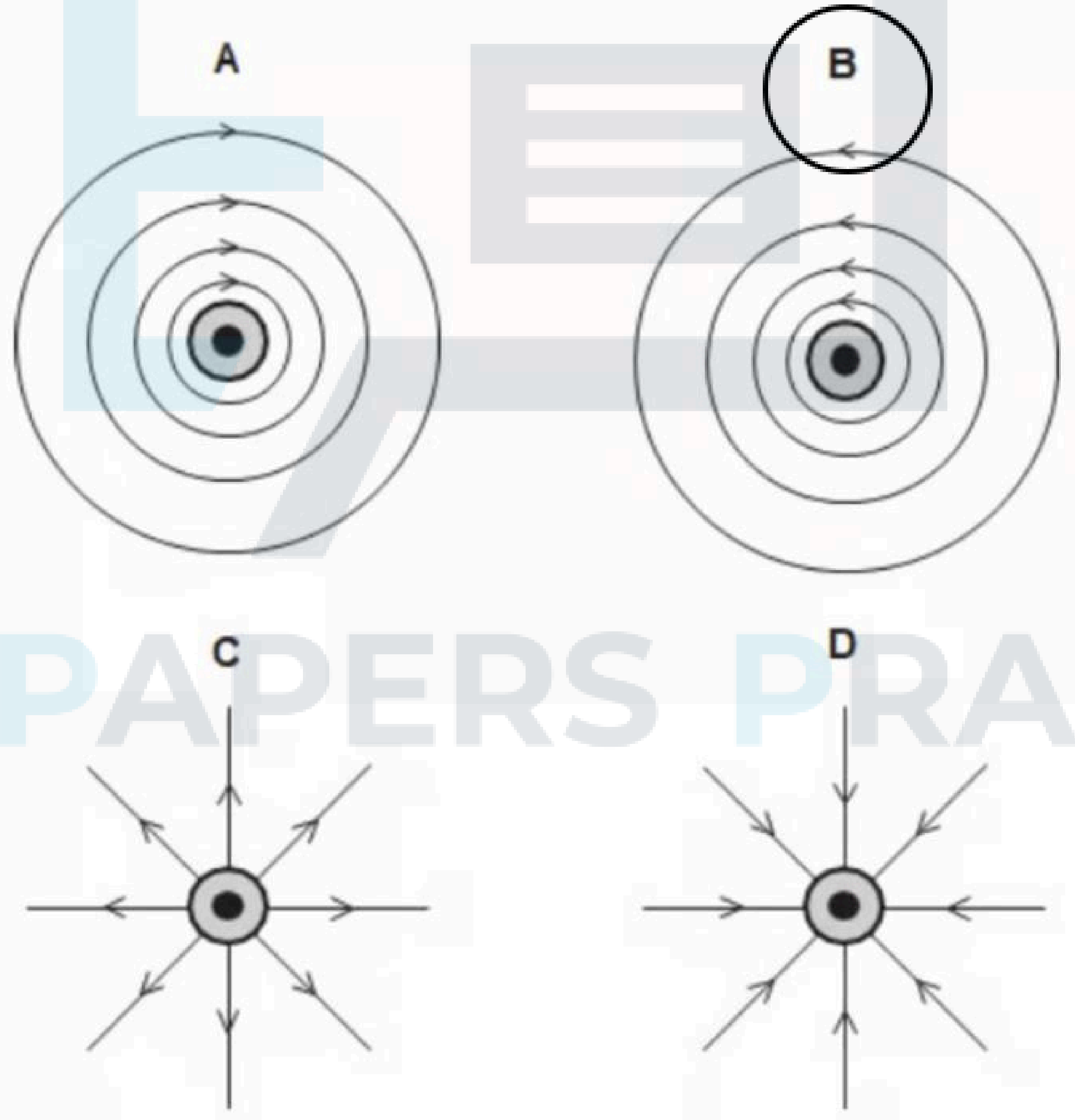
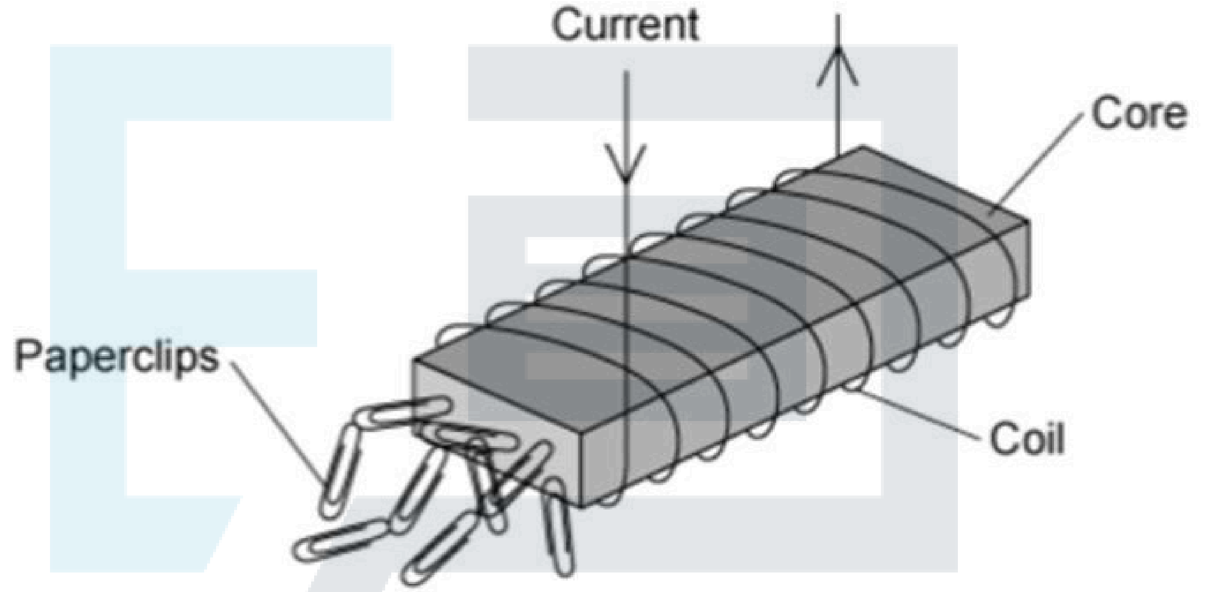


Which is correct?

PYQ

The diagram below shows an electromagnet. A student wants to find out how strong the magnetic field is by counting the number of metal pins it can pick up.



The experiment is repeated but the current in the coil is doubled. What would happen to the number of pins attracted to the electromagnet?

A More pins would be attracted.

B Some pins would fall off.

C The number of pins would stay the same.

D No pins would be attracted.

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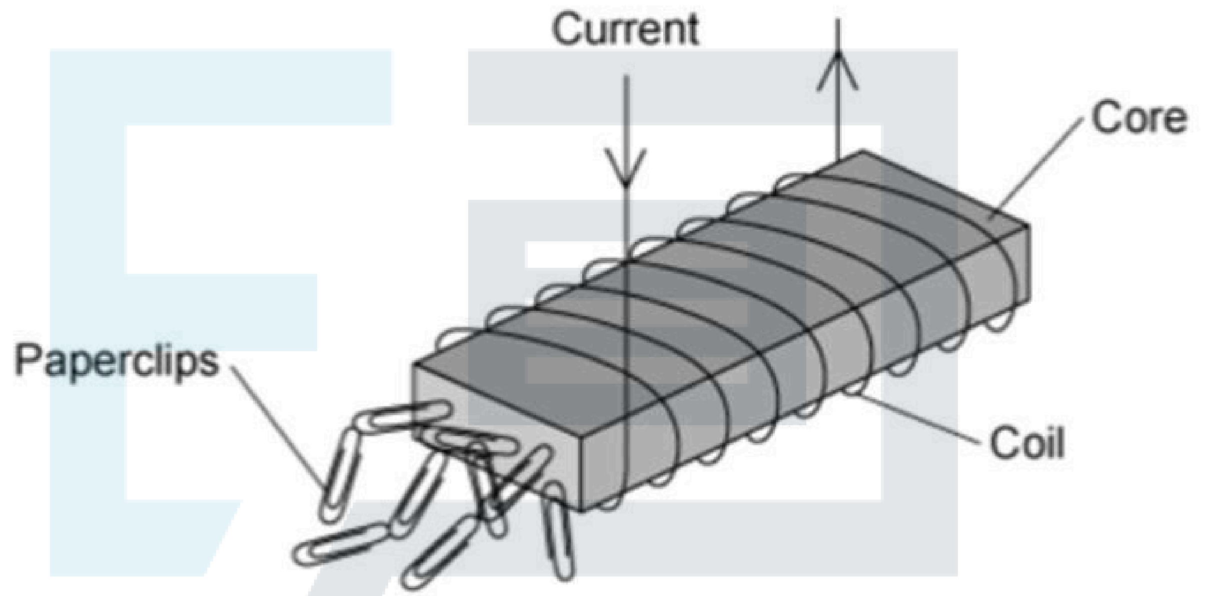

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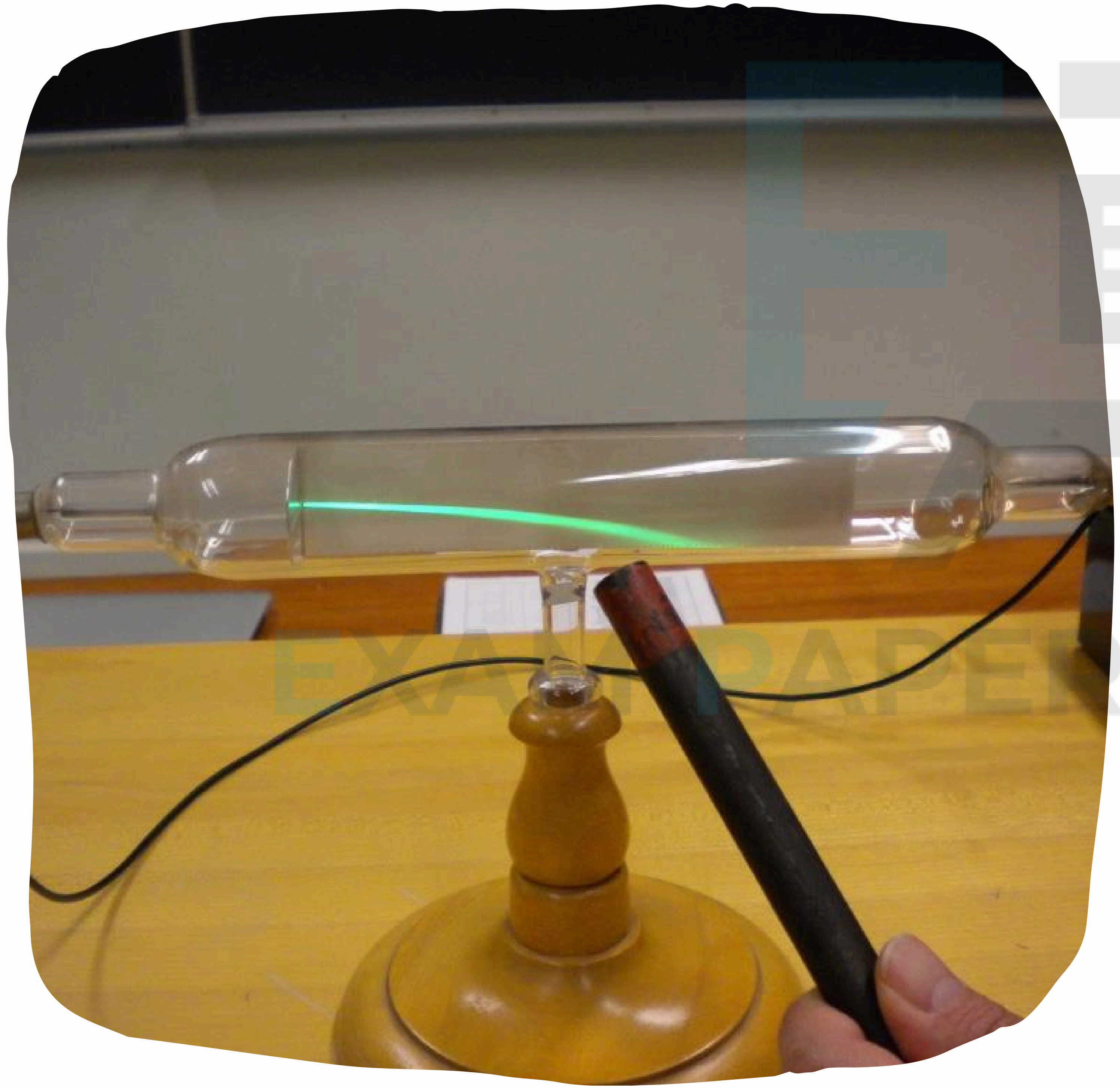
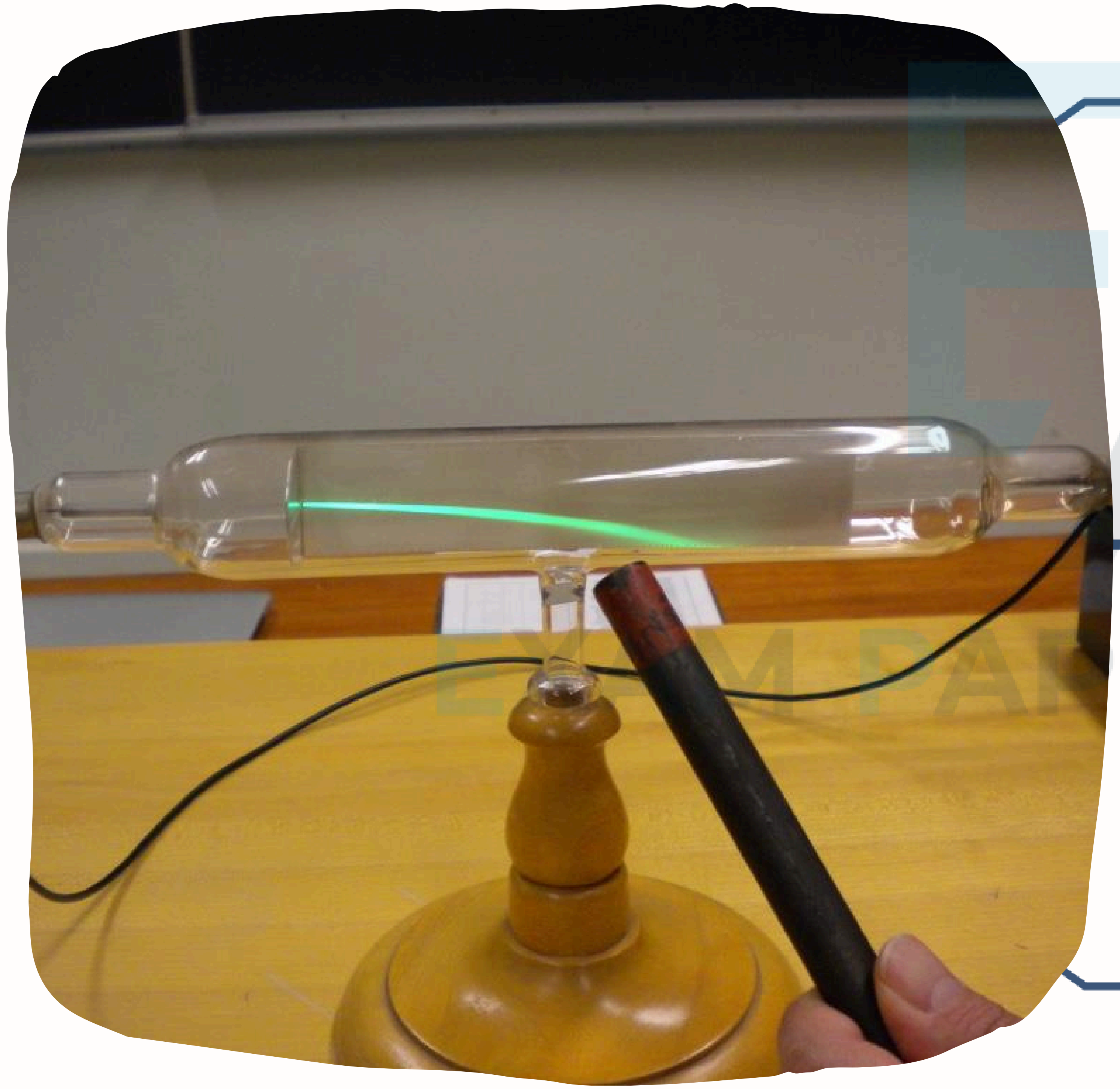
20.4 Beams of charged particles and magnetic fields



A magnetic field can also be used to deflect a beam of electrons, or any electrically charged particles.

20.4 Beams of charged particles and magnetic fields



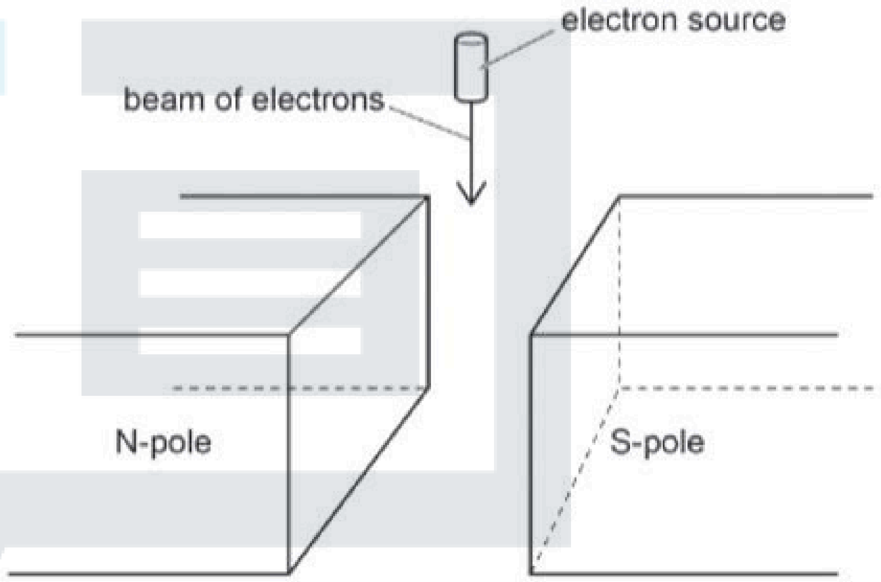
1. In the setup described, an electron beam travels from left to right within a vacuum tube.

2. A magnet positioned near the beam generates a magnetic field that interacts with the beam's own magnetic field due to its current flow. This interaction produces a force that deflects the electron beam.

3. Reversing the polarity of the magnet will reverse the direction of the deflection.

An electron source produces a narrow beam of electrons that all travel at the same speed.

The electron source is placed in a vacuum and the beam of electrons travels vertically downwards. The diagram shows the beam of electrons before it passes between the N-pole and the S-pole of a magnet.



(a) Describe what is meant by the direction of a magnetic field. State the direction of the magnetic field between the two poles in the diagram.

....

....

.... [1]

(b) Describe and explain what happens to the beam of electrons in the magnetic field between the poles of the magnet in the diagram.

....

....

....

.... [3]

[Total: 4]

Question	Answer	Marks
1(a)	the direction of the force on a N-pole **AND** left to right / N to S	1
1(b)	beam deflects (1) beam deflects <u>into</u> the page (1) moving electrons / charges constitute a current **OR** left-hand rule **OR** moving electrons / current in a magnetic field experiences a force (1)	3

The diagram represents a current in a wire. The current is into the plane of the paper.

(a) Draw the pattern of the magnetic field produced around the wire. Show clearly the direction of the magnetic field.

[2]

(b) The direction of the current in the wire is reversed. The magnitude of the current is unchanged.

State the effect that reversing the current has on the magnetic field produced.

Question

....

.... [1]

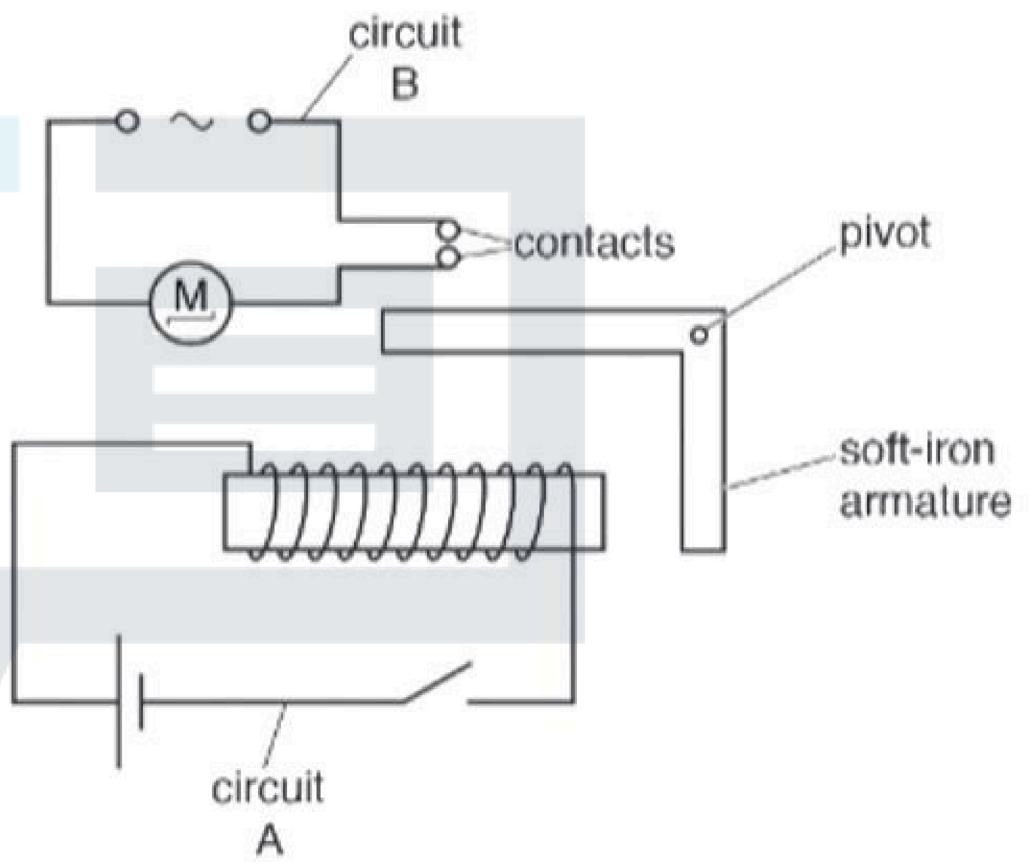
[Total: 3]

Mark scheme

Question	Answer	Marks
1(a)	at least 3 concentric circles (1) closer together near the wire **AND** clockwise arrow (1)	2
1(b)	arrows **or** field reverses / is in opposite direction	1

The diagram shows a relay.

Question



Circuit A contains a switch that operates the motor in circuit B when it is closed.

The soft-iron armature is replaced with a steel armature. The switch in circuit A is closed.

Explain what happens when the switch in circuit A is then opened.

....

....

.... [2]

[Total: 2]

1	current in circuit B does not stop when switch in circuit A is opened (1) steel remains magnetised when there is no current in the coil (1)	2