

20.4 Magnetic fields due to currents

Name: _____ Class: _____ Date: _____

Total: 22 marks

KEY WORDS solenoid 螺线管 • iron core 铁芯 • coil 线圈 • current 电流 • magnetic field 磁场

Objective

Build the skills to answer exam questions on **magnetic fields due to currents** and the force between currents.

You must be able to:

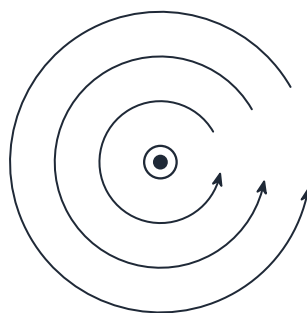
- sketch the field of a straight wire, a coil and a **solenoid**
- explain the **force between parallel currents**

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

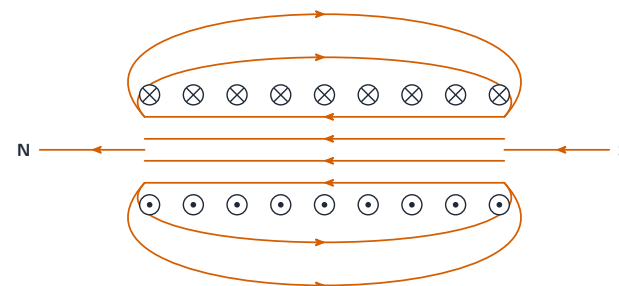
■ Field around a wire

A current in a long straight wire makes **concentric circular** field lines (use the **right-hand grip rule**):



current out of page

field nearly uniform inside, spreads out like a bar magnet outside



The magnetic field of a solenoid

A **solenoid** makes a field like a bar magnet (uniform inside); adding a **ferrous (iron) core** makes it much stronger.

■ Force between parallel currents

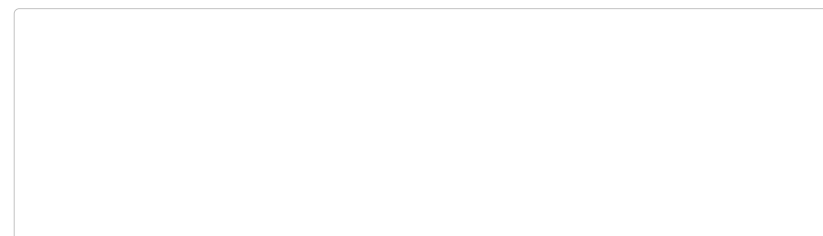
Each wire sits in the other's field. By Fleming's left-hand rule:

- currents in the **same** direction → **attract**;
- currents in **opposite** directions → **repel**.

2 Practice

Now apply the methods above.

2.1 A long straight wire carries a current **into** the page. In the space below, sketch the magnetic field pattern in the plane of the page, marking the **direction** of the field. State what happens to the pattern when the current is **reversed**. [3]



2.2 State **one** way to make a **solenoid's** field stronger. [1]

2.3 State whether two parallel currents in the **same** direction attract or repel. [1]

3 Exam-style questions

3.1 Two parallel wires carry currents in the **same** direction. They: [1]

- | | |
|---|---|
| A | B |
| C | D |
- A attract
B repel
C feel no force
D rotate

3.2 Sketch the magnetic field pattern around a long straight current-carrying wire. [2]

3.3 Explain why two **antiparallel** currents (opposite directions) **repel**. [2]

3.4 A long solenoid of length 0.35 m has 700 turns and carries a current of 2.4 A. A long straight wire runs parallel to its axis some distance away.

(a) **State** the shape of the magnetic field **inside** a long solenoid, away from its ends. [2]

(b) In the space below, **draw** the field pattern of a long straight wire carrying a current **out of** the page, showing at least three field lines and their direction. [3]

(c) **State** two ways of increasing the flux density inside the solenoid **without** changing its current. [2]

(d) A small coil of 50 turns and cross-sectional area $1.8 \times 10^{-4} \text{ m}^2$ is placed at the centre of the solenoid, with its plane perpendicular to the axis. The flux density there is $6.0 \times 10^{-3} \text{ T}$. **Determine** the magnetic flux linkage of the small coil. [3]

(e) The current in the solenoid is switched off, falling to zero in 0.020 s. **Determine** the average e.m.f. induced in the small coil. [2]