

12.3 Magnetism and Current-Carrying Wires

Name: _____ Class: _____ Date: _____

Total: 10 marks

Objective

Build the skills to answer exam questions on **magnetism and current-carrying wires**.

You must be able to:

- describe the field around a long straight **current-carrying wire** 载流导线, $B = \frac{\mu_0 I}{2\pi r}$
- calculate the force on a current-carrying wire in a field, $F = BI\ell \sin \theta$
- explain the attraction or repulsion between two parallel wires

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Field around a wire

$B = \frac{\mu_0 I}{2\pi r}$, with $\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$; the field circles the wire and weakens with distance.

■ Force on a wire

$F = BI\ell \sin \theta$ —maximum when the wire is perpendicular to the field.

■ Parallel wires

Currents in the **same** direction **attract**; in **opposite** directions they **repel**.

2 Practice

2.1 A wire of length 0.20 m carries 3.0 A perpendicular to a 0.50 T field. Find the force. [2]

2.2 State what happens to two parallel wires carrying current in the same direction. [1]

2.3 Find the magnetic field 0.10 m from a long wire carrying 5.0 A ($\mu_0 = 4\pi \times 10^{-7}$). [2]

3 Exam-style questions

3.1 The force on a current-carrying wire in a magnetic field is [1]

- **A** qvB
 - **B** $B I \ell$
 - **C** $\frac{\mu_0 I}{2\pi r}$
 - **D** V/R
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3.2 Two parallel wires carrying current in **opposite** directions [1]

- **A** attract
 - **B** repel
 - **C** do nothing
 - **D** always melt
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3.3 A 0.50 m wire carries 4.0 A at 90° to a 0.25 T field.

(a) Find the force on the wire. [2]

(b) State what happens to the force if the current is doubled. [1]

4 Go further

- work through the **12.3 Magnetism and Current-Carrying Wires** lesson on the **Learn** page;
- read the **Magnetism and Electromagnetic Induction** section of the AP Physics 2 handout on the **Know** page.

Solutions

2.1 $F = BI\ell = 0.50 \times 3.0 \times 0.20 = 0.30 \text{ N}.$

2.2 they attract each other.

2.3 $B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7})(5.0)}{2\pi(0.10)} = 1.0 \times 10^{-5} \text{ T}.$

3.1 B.

3.2 B.

3.3 (a) $F = BI\ell = 0.25 \times 4.0 \times 0.50 = 0.50 \text{ N}.$ (b) it doubles to 1.0 N ($F \propto I$).