Exercise walk-through

Magnetism and Current-Carrying Wires ▪ 12.3

eXercise

You must be able to

- describe the field around a long straight **current-carrying wire 载流导线**, $B = \dfrac{\mu_0 I}{2\pi r}$
- 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

Method — Field around a wire

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

Method — Force on a wire

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

Method — Parallel wires

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

Practice 2.1 ▪ 2 marks

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

Solution 2.1

Method: Force on a wire

Worked steps

$F = BI\ell = 0.50 \times 3.0 \times 0.20 = 0.30$ N **M1** **A1**.

Practice 2.2 ▪ 1 mark

State what happens to two parallel wires carrying current in the same direction.

Solution 2.2

Method: Parallel wires

Worked steps

they attract each other B1.

Practice 2.3 ▪ 2 marks

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

Solution 2.3

Method: Field around a wire

Worked steps

$$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7})(5.0)}{2\pi(0.10)} = 1.0 \times 10^{-5}\ \text{T}$$ M1 A1.

Exam-style 3.1 ▪ 1 mark

The force on a current-carrying wire in a magnetic field is

A qvB

B $BI\ell$

C $\dfrac{\mu_0 I}{2\pi r}$

D V/R

Solution 3.1

Method: Force on a wire

A qvB

B $BI\ell$ ✓

C $\dfrac{\mu_0 I}{2\pi r}$

D V/R

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

Two parallel wires carrying current in **opposite** directions

A attract

B repel

C do nothing

D always melt

Solution 3.2

Method: Parallel wires

A attract

B repel ✓

C do nothing

D always melt

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

A 0.50 m wire carries 4.0 A at 90° to a 0.25 T field.
(a) Find the force on the wire.
(b) State what happens to the force if the current is doubled.

Solution 3.3

Worked steps

(a) $F = BI\ell = 0.25 \times 4.0 \times 0.50 = 0.50$ N M1 A1. (b) it doubles to 1.0 N ($F \propto I$) B1.