Exercise walk-through

Ampère's Law ▪ 12.4

eXercise

You must be able to

- state **Ampère's law 安培定律**, $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{enc}}$
- choose an **Amperian loop 安培环路** whose symmetry makes $\vec{B}$ constant and parallel to the path
- apply it to a long straight wire and a cylindrical conductor
- derive the field inside a **solenoid 螺线管**, $B = \mu_0 n I$

Method — Ampère's law

$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{enc}}$: the field integrated around a closed loop equals μ_0 times the enclosed current.

Method — Choose the symmetry

Pick a loop on which B is constant and parallel to the path, so $\oint \vec{B} \cdot d\vec{l} = B \times (\text{length})$.

Method — Solenoid

Inside an ideal solenoid the field is uniform: $B = \mu_0 nI$, where n is the number of turns per metre. Ampère's law is easier than Biot-Savart whenever such symmetry exists.

Practice 2.1 ▪ 1 mark

State Ampère's law.

Solution 2.1

Worked steps

the line integral of $\vec{B}$ around a closed loop equals μ_0 times the enclosed current **B1**.

Practice 2.2 ▪ 2 marks

Find the field inside a solenoid of 500 turns per metre carrying 2.0 A ($\mu_0 = 4\pi \times 10^{-7}$).

Solution 2.2

Method: Solenoid

Worked steps

$B = \mu_0 nI = (4\pi \times 10^{-7})(500)(2.0) = 1.3 \times 10^{-3}$ T **M1** **A1**.

Practice 2.3 ▪ 1 mark

State when Ampère's law is easier to use than the Biot-Savart law.

Solution 2.3

Method: Solenoid

Worked steps

when the current has enough symmetry to make B constant and parallel along a chosen loop **B1**.

Exam-style 3.1 ▪ 1 mark

Ampère's law relates the field around a loop to the

A enclosed charge

B enclosed current

C magnetic flux

D voltage

Solution 3.1

Method: Ampère's law

A enclosed charge

B enclosed current ✓

C magnetic flux

D voltage

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

The field inside an ideal solenoid is

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

B $\mu_0 n I$

C $\dfrac{\mu_0 I}{2R}$

D zero

Solution 3.2

Method: Solenoid

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

B $\mu_0 n I$ ✓

C $\dfrac{\mu_0 I}{2R}$

D zero

Worked steps

B.

Exam-style 3.3 ▪ 1 mark

A solenoid has 1000 turns over a length of 0.50 m and carries 3.0 A ($\mu_0 = 4\pi \times 10^{-7}$).

(a) Find the number of turns per metre, *n*.

(b) Find the field inside.

Solution 3.3

Method: Solenoid

Worked steps

(a) $n = \dfrac{1000}{0.50} = 2000\ \text{m}^{-1}$ **B1**. (b) $B = \mu_0 n I = (4\pi \times 10^{-7})(2000)(3.0) = 7.5 \times 10^{-3}\ \text{T}$ **M1** **M1** **A1**.