

12.4 Ampère's Law

Name: _____ Class: _____ Date: _____

Total: 10 marks

Objective

Build the skills to answer exam questions on **Ampère's law**.

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, $B = \mu_0 n I$

1 Worked examples

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

■ 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.

■ Choose the symmetry

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

■ Solenoid

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

2 Practice

2.1 State Ampère's law.

[1]

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

[2]

2.3 State when Ampère’s law is easier to use than the Biot-Savart law. [1]

3 Exam-style questions

3.1 Ampère’s law relates the field around a loop to the [1]

- **A** enclosed charge
 - **B** enclosed current
 - **C** magnetic flux
 - **D** voltage
-

3.2 The field inside an ideal solenoid is [1]

- **A** $\frac{\mu_0 I}{2\pi r}$
 - **B** $\mu_0 n I$
 - **C** $\frac{\mu_0 I}{2R}$
 - **D** zero
-

3.3 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 . [1]

(b) Find the field inside. [3]

4 Go further

- work through the **12.4 Ampère’s Law** lesson on the **Learn** page;
 - read the **Magnetic Fields** section of the AP Physics C: E&M handout on the **Know** page.
-

Solutions

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

2.2 $B = \mu_0 n I = (4\pi \times 10^{-7})(500)(2.0) = 1.3 \times 10^{-3} \text{ T}$.

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

3.1 B.

3.2 B.

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