AP PHYSICS C: ELECTRICITY AND MAGNETISM • EXERCISE SHEET

12.4 Ampère's Law

Name: ______________ Class: __________ Date: ____________ **Total: 10 marks**

KEY WORDS solenoid 螺线管 • amperian loop 安培环路 • ampère's law 安培定律

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, $B = \mu_0 nI$

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: $B = \mu_0 nI$, 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** $\dfrac{\mu_0 I}{2\pi r}$
- **B** $\mu_0 n I$
- **C** $\dfrac{\mu_0 I}{2R}$
- **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]

Solutions

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

2.2 $B = \mu_0 n I = (4\pi \times 10^{-7})(500)(2.0) = 1.3 \times 10^{-3}$ 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) $n = \dfrac{1000}{0.50} = 2000\ \text{m}^{-1}$. (b) $B = \mu_0 n I = (4\pi \times 10^{-7})(2000)(3.0) = 7.5 \times 10^{-3}$ T.