

Exercise walk-through

12.4

Ampère's Law

AP Physics C: Electricity and Magnetism

Ampère's law

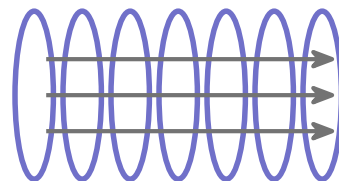
For enough symmetry, Ampère's law beats integrating Biot-Savart:

The loop integral

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$$

Choose an **Amperian loop** where B is constant and parallel, so the integral becomes $B \times \text{length}$.

Inside a **solenoid** : $B = \mu_0 nI$, uniform.



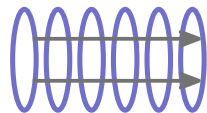
$$B = \mu_0 nI$$

Exam tips

- The magnetic force $\vec{F} = q\vec{v} \times \vec{B}$ is **perpendicular** to velocity – use the right-hand rule and note it does **no work**.
- A charge in a uniform field moves in a circle with $r = \frac{mv}{qB}$.
- Find the field of currents with **Biot–Savart** $d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{l} \times \hat{r}}{r^2}$ or **Ampère's law** $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$ when there is symmetry.
- Force on a wire is $\vec{F} = I\vec{L} \times \vec{B}$; keep the cross-product direction straight.
- Distinguish the force **on** a charge from the field the current **creates**.

Check yourself

- 1 Why does the magnetic force on a moving charge do no work?
- 2 Which law gives the field of a symmetric current quickly?
- 3 Double the distance from a straight wire – what happens to B ?
- 4 Is the field inside an ideal solenoid uniform?



Answers 1. it is perpendicular to $\vec{v}$ 2. Ampère's law 3. it halves 4. yes

Exercises 2.1-2.3

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]

Exercises 2.1-2.3

2.1 State Ampère's law. [1]

2.1

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

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]

2.2

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

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

2.3

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

Exercises 3.1-3.2

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

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3.1 B

- enclosed current.

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- A $\frac{\mu_0 I}{2\pi r}$
- B $\mu_0 n I$
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3.2 B

- $\mu_0 n I$.

Exercise 3.3 (a)

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]

Exercise 3.3 (a)

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(a) Find the number of turns per metre, n . [1]

(a)

- $$n = \frac{1000}{0.50} = 2000 \text{ m}^{-1}$$

Exercise 3.3 (b)

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

(b) Find the field inside.

[3]

Exercise 3.3 (b)

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

(b) Find the field inside. [3]

(b)

- $B = \mu_0 n I = (4\pi \times 10^{-7})(2000)(3.0) = 7.5 \times 10^{-3} \text{ T}$