

12.2 Magnetism and Moving Charges

Name: _____ Class: _____ Date: _____

Total: 11 marks

Objective

Build the skills to answer exam questions on **magnetism and moving charges**.

You must be able to:

- calculate the **magnetic force** 磁力 on a moving charge, $\vec{F} = q\vec{v} \times \vec{B}$
- use the **right-hand rule** 右手定则 for the direction of $\vec{v} \times \vec{B}$
- explain why the magnetic force does **no work**
- analyse the **circular motion** of a charge in a uniform field, $r = \frac{mv}{qB}$

1 Worked examples

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

■ Force on a moving charge

$\vec{F} = q\vec{v} \times \vec{B}$, with magnitude $F = qvB \sin \theta$ and direction from the right-hand rule.

■ No work

Because $\vec{F} \perp \vec{v}$, the magnetic force does **no work**—it changes only the **direction** of the velocity, not the speed.

■ Circular motion

For $\vec{v} \perp \vec{B}$, the force provides the centripetal force: $qvB = \frac{mv^2}{r}$, so $r = \frac{mv}{qB}$.

2 Practice

2.1 A charge of 3.0×10^{-6} C moves at 2.0×10^4 m s⁻¹ perpendicular to a 0.40 T field. Find the force. [2]

2.2 Explain why the magnetic force does no work on a moving charge. [2]

2.3 Write the formula for the radius of a charge's circular path in a magnetic field. [1]

3 Exam-style questions

3.1 The magnetic force on a moving charge is [1]

- A $q\vec{E}$
- B $q\vec{v} \times \vec{B}$
- C $I\vec{L}$
- D $m\vec{a}$

3.2 The magnetic force on a moving charge does [1]

- A positive work
- B negative work
- C no work
- D maximum work

3.3 A proton ($q = 1.6 \times 10^{-19}$ C, $m = 1.67 \times 10^{-27}$ kg) moves at 4.0×10^6 m s⁻¹ perpendicular to a 0.50 T field.

(a) Find the magnetic force on it. [2]

(b) Find the radius of its circular path. [2]

4 Go further

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- work through the **12.2 Magnetism and Moving Charges** 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 $F = qvB = (3.0 \times 10^{-6})(2.0 \times 10^4)(0.40) = 2.4 \times 10^{-2} \text{ N}.$

2.2 the force is perpendicular to the velocity, so $\vec{F} \cdot \vec{v} = 0$ and no work is done —only the direction changes.

2.3 $r = \frac{mv}{qB}.$

3.1 B.

3.2 C.

3.3 (a) $F = qvB = (1.6 \times 10^{-19})(4.0 \times 10^6)(0.50) = 3.2 \times 10^{-13} \text{ N}.$ (b) $r = \frac{mv}{qB} = \frac{(1.67 \times 10^{-27})(4.0 \times 10^6)}{(1.6 \times 10^{-19})(0.50)} = 0.084 \text{ m}.$