Exercise walk-through

Magnetism and Moving Charges ▪ 12.2

eXercise

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, $r = \dfrac{mv}{qB}$

Method — 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.

Method — 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.

Method — Circular motion

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

Practice 2.1 ▪ 2 marks

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.

Solution 2.1

Method: Force on a moving charge

Worked steps

$F = qvB = (3.0 \times 10^{-6})(2.0 \times 10^{4})(0.40) = 2.4 \times 10^{-2}$ N M1 A1.

Practice 2.2 ▪ 2 marks

Explain why the magnetic force does no work on a moving charge.

Solution 2.2

Method: No work

Worked steps

the force is perpendicular to the velocity B1, so $\vec{F} \cdot \vec{v} = 0$ and no work is done — only the direction changes B1.

Practice 2.3 ▪ 1 mark

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

Solution 2.3

Worked steps

$r = \dfrac{mv}{qB}$ B1.

Exam-style 3.1 ▪ 1 mark

The magnetic force on a moving charge is

A $q\vec{E}$

B $q\vec{v} \times \vec{B}$

C $I\vec{L}$

D $m\vec{a}$

Solution 3.1

Method: Force on a moving charge

A $q\vec{E}$

B $q\vec{v} \times \vec{B}$ ✓

C $I\vec{L}$

D $m\vec{a}$

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

The magnetic force on a moving charge does

A positive work

B negative work

C no work

D maximum work

Solution 3.2

A positive work

B negative work

C no work ✓

D maximum work

Worked steps

C.

Exam-style 3.3 ▪ 2 marks

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.

(b) Find the radius of its circular path.

Solution 3.3

Worked steps

(a) $F = qvB = (1.6 \times 10^{-19})(4.0 \times 10^{6})(0.50) = 3.2 \times 10^{-13}$ N M1 A1. (b) $r = \dfrac{mv}{qB} = \dfrac{(1.67 \times 10^{-27})(4.0 \times 10^{6})}{(1.6 \times 10^{-19})(0.50)} = 0.084$ m M1 A1.