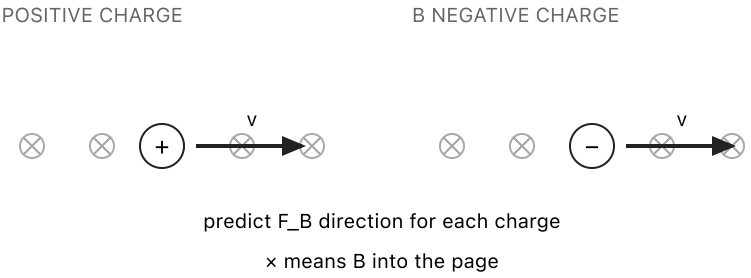
MAGNETISM DAY 3: FORCE ON MOVING CHARGES & THE RIGHT-HAND RULE

CED 12.2 · Skill 2.B · FRQ: MR

PREDICT THE DIRECTION

A positive charge moves right through a magnetic field into the page. Predict $\vec{F}_B$: **up / down / right / into the page**. Commit before the force arrow is revealed.

PAGE-SYMBOL GEOMETRY — × MEANS INTO THE PAGE



MAGNITUDE

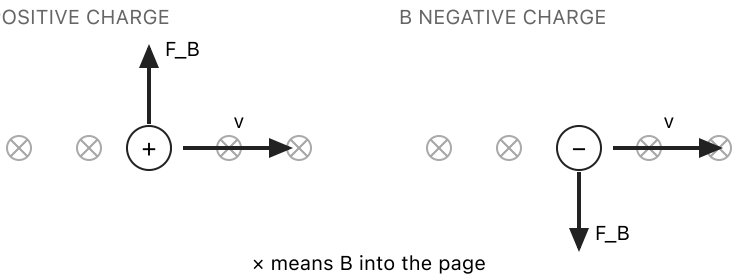
$$F_B = |q|vB\sin\theta$$

θ is the angle between $\vec{v}$ and $\vec{B}$. The force is largest when the vectors are perpendicular and zero when they are parallel or antiparallel.

WE DO A $+3.0\,\mu\text{C}$ charge moves at $4.0 \times 10^5\,\text{m/s}$ through a $0.25\,\text{T}$ field at 30°. Find the force magnitude.

DIRECTION

THE CHARGE SIGN REVERSES THE FORCE

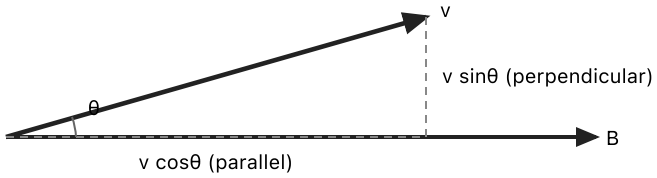


1. For a positive charge, point fingers with $\vec{v}$ and curl toward $\vec{B}$. The thumb gives $\vec{F}_B$.
2. For a negative charge, reverse that result.
3. Check that a nonzero result is perpendicular to both $\vec{v}$ and $\vec{B}$.

REASON A negative charge moves left through a field out of the page. Determine the force direction and show the positive-charge intermediate direction before reversing it.

ANGLE AND WORK

ONLY V PERPENDICULAR CONTRIBUTES TO THE FORCE MAGNITUDE



only the perpendicular component contributes to |F_B|

The component parallel to $\vec{B}$ produces no magnetic force. The perpendicular component gives $F_B = |q|v_\perp B$.
A nonzero magnetic force is perpendicular to the instantaneous velocity, so

$$P = \vec{F}_B \cdot \vec{v} = 0 \qquad W_B = 0 \qquad \Delta K = 0$$

The magnetic force can turn the velocity without changing the particle's speed.

COMPARE For the same q, v, B, rank the force magnitude at 0°, 30°, and 90°. State the speed change in each case if no other force acts.

PRACTICE

1. A positive charge moves right through B into the page. State the force direction.

2. Repeat for a negative charge with the same velocity and field.

3. Find F_B for $|q| = 1.2\,\mu\text{C}$, $v = 7.0 \times 10^5\,\text{m/s}$, $B = 0.30\,\text{T}$, and $v \perp B$.

4. Find the magnetic force when $v \parallel B$.

5. A magnetic field bends a particle's path. Explain why the particle's kinetic energy remains constant.