

Motion in electromagnetic fields · supported focus

International Baccalaureate · IB Diploma · Physics · HL

Scope and prerequisites

Supported HL focus. First assessment 2025; full Physics guide acquired (84 PDF pages). Remaining guide, assessment and practical requirements retain their recorded holds.

Prerequisites: read the stated quantities and units, use arithmetic and the model conditions below. Each lesson develops its own method before independent transfer.

These are original or explicitly fictional teaching examples, not actual measurements or completed assessed learner investigations.

Magnetic forces: turn velocity without increasing speed

■ What would explain this observation?

- A charged particle curves in a uniform magnetic field. Its direction changes although the **magnetic force** alone does not increase its kinetic energy.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- The magnetic force magnitude is $F = |q|vB \sin\theta$. It is perpendicular to velocity and magnetic field, with direction determined by charge sign. For perpendicular entry into a uniform field, it can provide the centripetal force for circular motion.
- magnetic force: Force due to a magnetic field on a moving charge or current; **momentum**: Mass multiplied by velocity in the classical model.



■ Choose evidence that can test it

- Equate magnetic force with mv^2/r to obtain $r = mv/(|q|B)$ for perpendicular motion. A stronger field makes a smaller radius at fixed momentum. Parallel entry gives zero magnetic force in this model.
- Draw velocity, field and force as separate arrows using stated into/out-of-page conventions. Use supplied beam data or a simulation. Do not treat a current-carrying wire direction as identical to electron-motion direction.

■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: a particle has $m = 2.0 \times 10^{-27}$ kg, $v = 3.0 \times 10^6$ m/s, $|q| = 1.0 \times 10^{-19}$ C and $B = 0.20$ T. $r = mv/(|q|B) = 0.30$ m. The calculation assumes non-relativistic motion and perpendicular entry.

Example:

Use $r = mv/(|q|B)$. For $m = 2 \times 10^{-27}$ kg, $v = 2 \times 10^6$ m/s, $|q| = 1 \times 10^{-19}$ C and $B = 0.20$ T, find r . Use the same sequence: known quantities → model → relation → substitution → unit and interpretation.

■ Check the conclusion and its limits

- A magnetic force can change momentum direction without doing work. Adding an electric field can change the energy, so conclusions about a magnetic field alone do not cover every combined-field apparatus.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

A magnetic force alone continuously increases the kinetic energy of a charged particle. This claim is false: A magnetic force can change momentum direction without doing work. Adding an electric field can change the energy, so conclusions about a magnetic field alone do not cover every combined-field apparatus.

Key:

Magnetic forces: turn velocity without increasing speed: Equate magnetic force with mv^2/r to obtain $r = mv/(|q|B)$ for perpendicular motion. A stronger field makes a smaller radius at fixed momentum. Parallel entry gives zero magnetic force in this model.