

Magnetism & Electromagnetism

AP Physics 2 ■ Unit 12

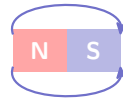
AP Physics 2



Magnetism & Electromagnetism

What we will cover

- 1 Magnetic fields
- 2 Force on a moving charge
- 3 Current-carrying wires
- 4 Electromagnetic induction



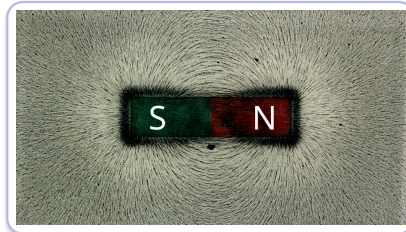
1 Magnetic fields

Magnetic fields

A **magnetic field** 磁场 $\vec{B}$ is made by **magnets** 磁铁 or **moving** charges (a still charge makes none).

- unlike **poles** 磁极 attract; like poles repel
- lines run $N \rightarrow S$ outside, in closed loops

Cut a magnet in half $\Rightarrow$ two magnets – there is **no magnetic monopole**.



Magnets produce field patterns in space

2 Moving charges

Force on a moving charge

A field pushes a charge only when it **moves**:

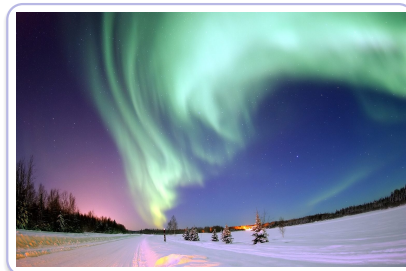
Magnetic force

$$F = qvB \sin \theta$$

Perpendicular to *both* $\vec{v}$ and $\vec{B}$ (right-hand rule). Zero if $v \parallel B$.

Perpendicular entry $\Rightarrow$ a circle:

$$qvB = \frac{mv^2}{r}, \text{ so } r = \frac{mv}{qB}.$$



Moving charges feel magnetic forces

3 Wires

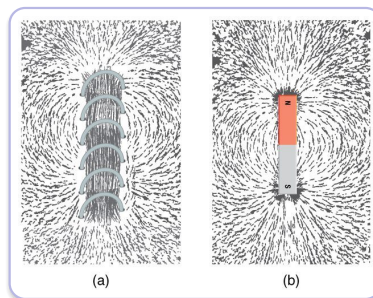
Current-carrying wires

A current makes its own field (circles around the wire), and a field pushes on a current:

Field and force

$$B = \frac{\mu_0 I}{2\pi r}, \quad F = BIl \sin \theta$$

Two parallel wires: **same** direction attract, opposite repel. (The opposite of charges!)



Currents produce magnetic fields

4 Induction

Electromagnetic induction

A **changing magnetic flux** 磁通量 through a loop induces a voltage:

Flux and Faraday's law

$$\Phi = BA \cos \theta, \quad \varepsilon = -\frac{\Delta \Phi}{\Delta t}$$

Lenz's law 楞次定律 (the minus sign): the induced current **opposes the change** – energy conservation.



Induction moves energy between coils

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Recap

Unit 12 – key takeaways

1 Fields

lines N→S in closed loops; no monopoles

2 Moving charge

$F = qvB \sin \theta$, $\perp$ to v and B ;
circle $r = mv/qB$

3 Wires

$F = BIl \sin \theta$; parallel same-direction currents attract

4 Induction

changing flux $\Rightarrow$ emf; Lenz opposes the change

Check yourself

- 1 Does a stationary charge feel a magnetic force?
- 2 A charge moves parallel to B – what is the force?
- 3 Two wires carry current the same way – attract or repel?
- 4 What must change to induce an emf in a loop?



Answers 1. no 2. zero 3. attract 4. the flux (B , A , or θ)