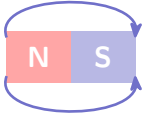
# Magnetism & Electromagnetism

## AP Physics 2 ▪ Unit 12

AP Physics 2

# What we will cover

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



# Magnetic fields

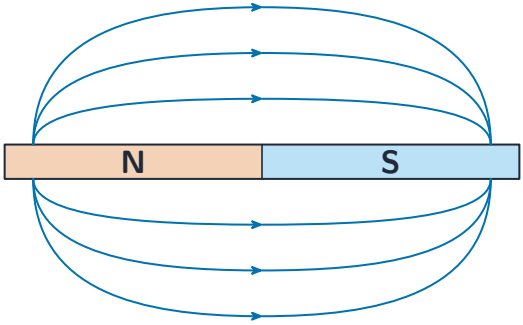
A **magnetic field** 磁场 $\vec{B}$ is made by **magnets** 磁铁 or moving charges (a still charge makes none).

- 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*

# Magnetic fields



# Force on a moving charge

A field pushes a charge only when it moves:

## Magnetic force

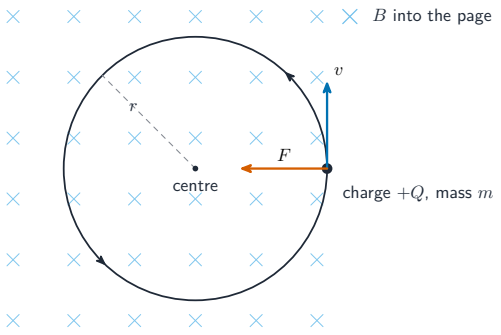
$$F = qvB\sin\theta$$

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

Perpendicular entry $\Rightarrow$ a circle: $qvB = \frac{mv^2}{r}$, so $r = \frac{mv}{qB}$.

*Moving charges feel magnetic forces*

# Force on a moving charge




$$BQv = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{BQ}$$

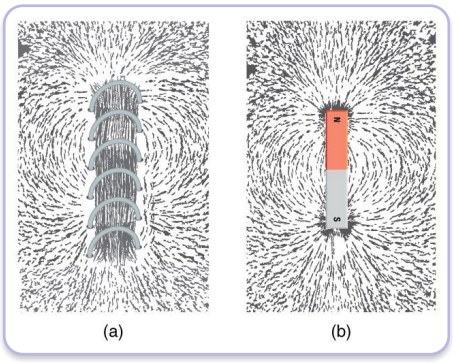
# Current-carrying wires

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

**Field and force**

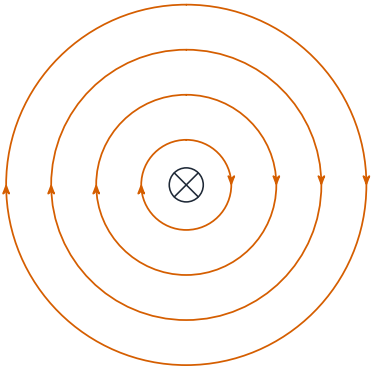
$$B = \frac{\mu_0 I}{2\pi r}, \qquad F = BI\ell \sin\theta$$

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




*Currents produce magnetic fields*

# Current-carrying wires



current $I$
into the page

circular field lines (right-hand grip rule)

# Electromagnetic induction

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

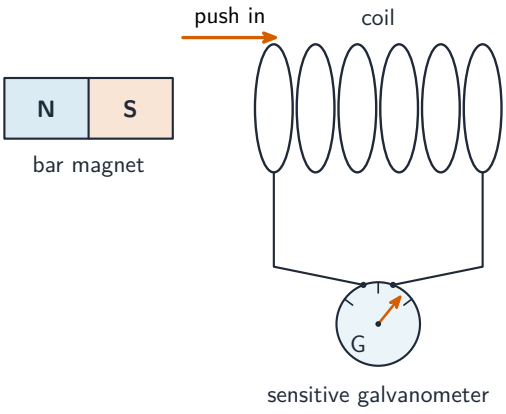
## Flux and Faraday's law

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

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


*Induction moves energy between coils*

# Electromagnetic induction



# 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**

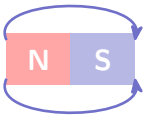
$F = BI\ell\sin\theta$; parallel same-direction currents attract

**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 $\theta$)