

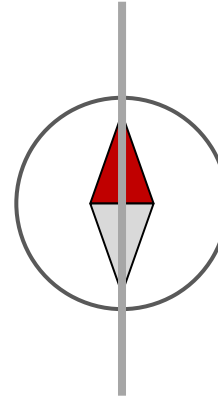
Essential Question

How can electricity make a magnet?

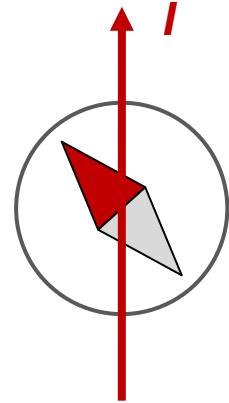
Oersted's Discovery

- Current in a wire turns a compass
- Moving charges make magnetic fields
- No current, no field

north ↑



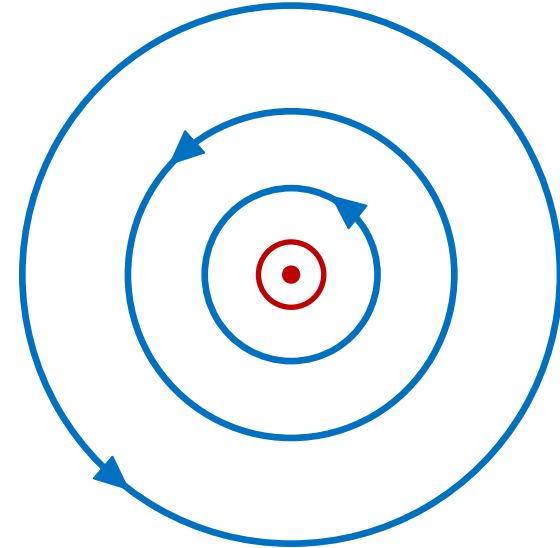
switch off



current on

Field Around a Wire

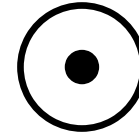
- Field lines are circles around the wire
- Closer to the wire: stronger
- More current: stronger



current out of the page

Dots and Crosses

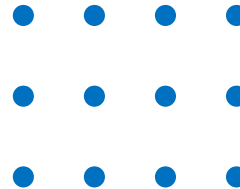
- Dot: out of the page, toward you
- Cross: into the page, away from you
- Used for both current and field



out of the page
(arrow tip)



into the page
(arrow tail)



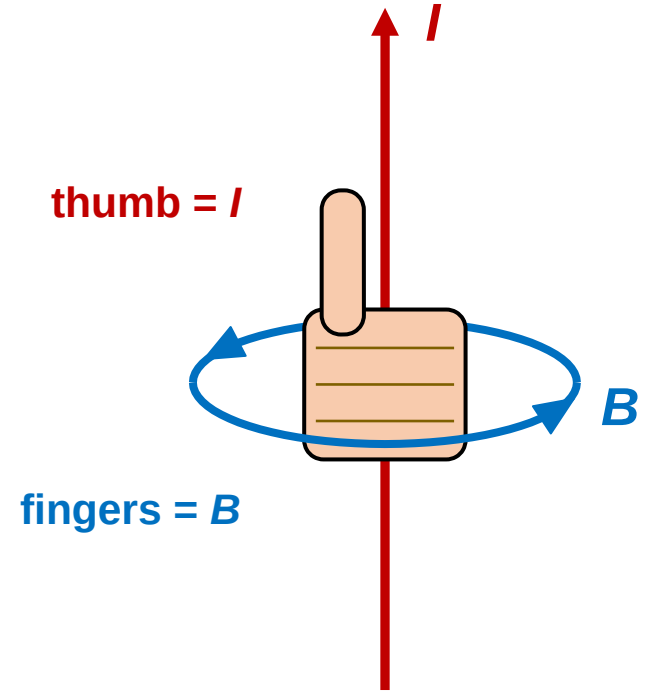
B out of page



B into page

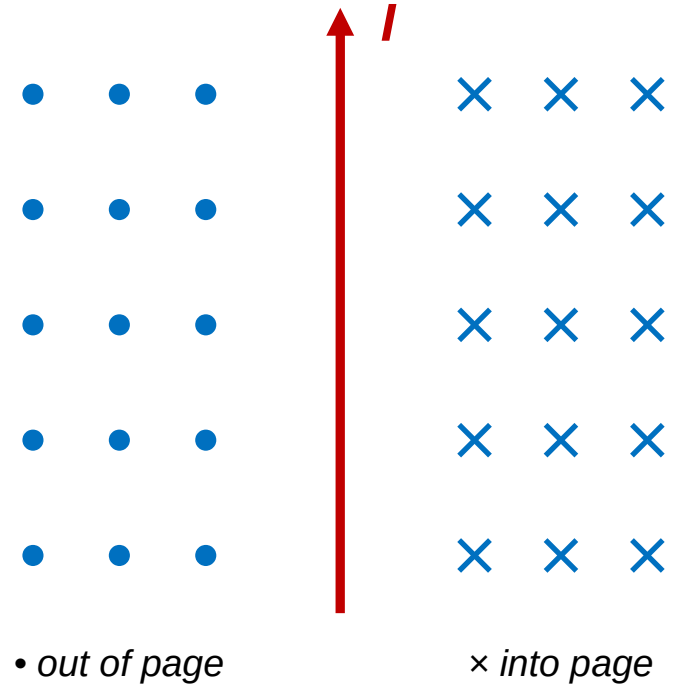
Right-Hand Grip Rule

- Thumb points along current I
- Fingers curl the way B circles
- I = conventional current (+ flow)



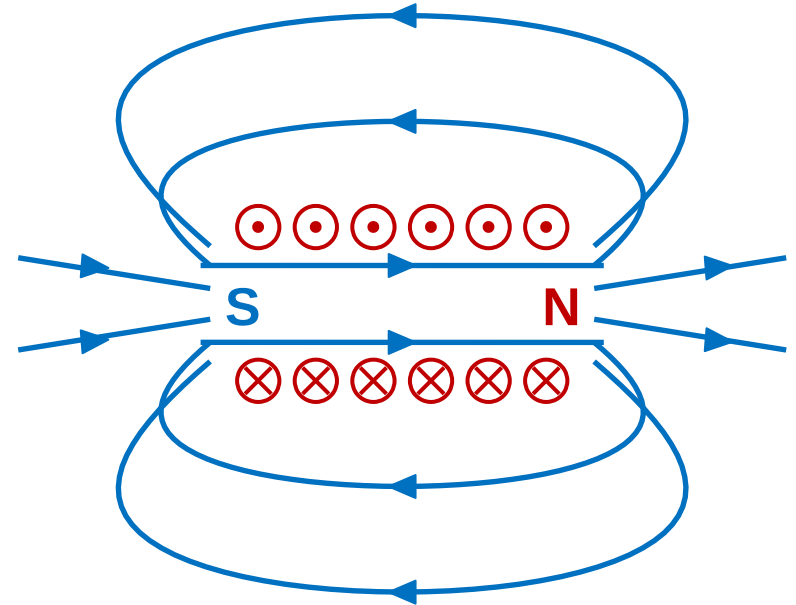
Wire in the Page

- Field pokes through the page
- Current up: $\times$ on the right
- Current up: $\bullet$ on the left



Field of a Coil

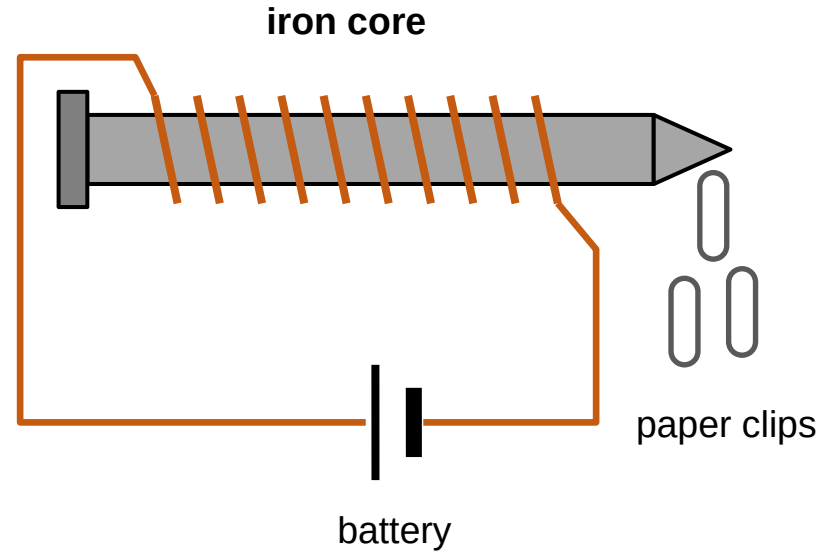
- Coil: many loops of wire
- Inside, the loops' fields add up
- A coil acts like a bar magnet



a coil's field looks like a bar magnet's

Electromagnets

- Coil wrapped around an iron core
- Current on: magnet. Current off: not
- Used in cranes, speakers, and doorbells



Making It Stronger

- More current
- More turns of wire
- An iron core inside

$$B \propto N \times I$$

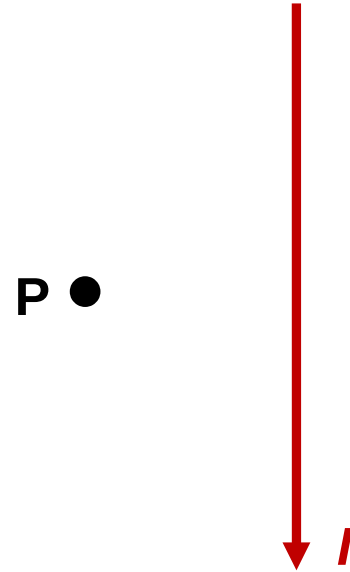
2 × current → 2 × field

2 × turns → 2 × field

iron core → much stronger

Example: Field Next to a Wire

A long straight wire carries current toward the bottom of the page. Does the magnetic field at point P, to the left of the wire, point into or out of the page?



Example: Current Out of the Page

A wire carries current straight out of the page. Which way does the magnetic field point at point P, directly above the wire?



current out of page

Example: Which End Is North?

This cut-away coil has crosses (current into the page) on the top row and dots (current out of the page) on the bottom row. Which end of the coil is its N pole?



Example: Stronger Electromagnet

An electromagnet has 100 turns of wire carrying 2.0 A. You rewind it with 300 turns and raise the current to 4.0 A. How many times stronger is its magnetic field?

Before

$$N = 100, I = 2.0 \text{ A}$$

After

$$N = 300, I = 4.0 \text{ A}$$

Big Ideas

- Moving charges (currents) make magnetic fields
- Grip rule: thumb = I , fingers curl = B
- • out of page, $\times$ into page
- Coil = electromagnet: $B \propto N \times I$, iron core helps