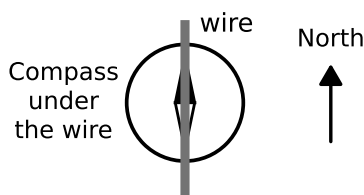


Part A: Fields Around Wires

Current means conventional current (+ flow). A dot ($\bullet$) means out of the page, toward you. A cross ($\times$) means into the page, away from you.

1. A long wire runs north and south directly over a compass, as shown. The switch is open, so the compass points north. What happens to the needle when the switch is closed? What happens when it is opened again? What does this show?

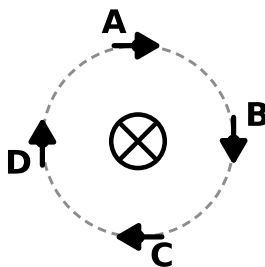


Closed: current flows and the needle swings away from north (it turns to line up with the wire's magnetic field).

Opened: no current, no field, so the needle swings back to point north.

Shows: an electric current (moving charge) makes a magnetic field. This is Oersted's discovery.

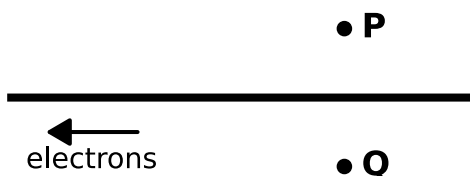
2. A long straight wire carries current straight into the page. Draw an arrow at each point, A through D, showing the direction of the magnetic field there. Does the field circle the wire clockwise or counterclockwise?



Thumb into the page: the fingers curl **clockwise** (as seen from the front).

A (above): **right**. **B** (right): **down**. **C** (below): **left**. **D** (left): **up**. Each arrow is tangent to the circle through the points.

3. Electrons flow to the left through the horizontal wire shown. Does the magnetic field at point P (above the wire) point into or out of the page? What about at point Q (below the wire)? Explain.



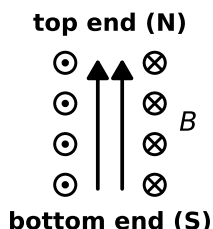
Conventional current: electrons move left, so the conventional current I points **right**.

Grip rule: thumb to the right. The fingers come up out of the page above the wire and go back into the page below it.

P: out of the page ($\odot$). Q: into the page ($\otimes$).

Part B: Field of a Coil

4. This cut-away view slices a vertical coil in half. The wires on the left carry current out of the page (dots) and the wires on the right carry current into the page (crosses).



- Which way does the magnetic field point inside the coil?
- Which end of the coil, top or bottom, is its N pole? Explain.
 - Left wires (current out): fingers curl counterclockwise, so just to their right (inside) the field points **up**. Right wires (current into): fingers curl clockwise, so just to their left (inside) the field also points **up**. Inside the coil, B points **up**.
 - Field lines come out of the **top end**, so the **top is the N pole** (and the bottom is S).

Part C: Electromagnets

5. Four electromagnets are the same length and have no iron cores. Use $B \propto N \times I$.

Electromagnet	Turns, N	Current, I (A)
A	100	2.0
B	50	6.0
C	200	0.50
D	150	4.0

- Rank the electromagnets from strongest field to weakest.
- How many times stronger is the field of D than the field of C?

Compare $N \times I$: A: $100 \times 2.0 = 200$. B: $50 \times 6.0 = 300$. C: $200 \times 0.50 = 100$. D: $150 \times 4.0 = 600$.

a. $D > B > A > C$

b. $600 \div 100 = 6.0$ times stronger

-
6. Lena's electromagnet has 250 turns of wire carrying 2.0 A. Her battery is getting weak, and the current drops to 1.0 A.
- How many turns would she need to get the same field as before?
 - Name one other way she could make her electromagnet stronger, and explain why it works.
- a. Before:** $N \times I = 250 \times 2.0 = 500$. **After:** $N \times 1.0 \text{ A}$ must also equal 500, so **$N = 500$ turns**. Halving the current means doubling the turns.
- b.** Add an **iron core** (such as a nail) inside the coil. The coil's field lines up the iron's domains, and their fields add to the coil's field, making it many times stronger. (Using a fresh battery to raise the current also works.)