Solving Circuit Problems

PHY 114-01

Fall 2026

Announcements

- Office hours today 11am-12pm and 2pm-3pm SENG 208b
- Midterm 2 next Friday 11/6
- No homework this week
- Practice exam posted on webpage

Metacognition and exam reflections

- Why do I ask you to explain your mistake?
  - Metacognition refers to **knowledge about one's own thoughts and cognitive processes**
  - Strong metacognition = strong problem solving

- Don’t beat yourself up. Just tell me what you did and why.
- Example: “I had no idea what to do, so I just wrote something off my cheat sheet that looked like it correlated.”
- Example: “I correctly identified that the charge distribution had a cylindrical symmetry and that Gauss’s Law could be used. However, I used the formula for an infinite line of charge without converting the surface charge densities into enclosed charge…”
- Partial credit: list of mistakes without explanation of reasoning.
- Next time: Don’t write what you *should have done*. Write what you did and why.

Agenda

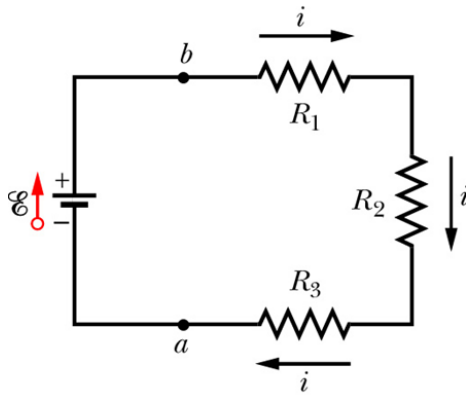
- Last time:
  - Electric power
  - Kirchoff's laws
  - Resistors in parallel and series

- Applying Kirchoff's laws

Resistors in Combination

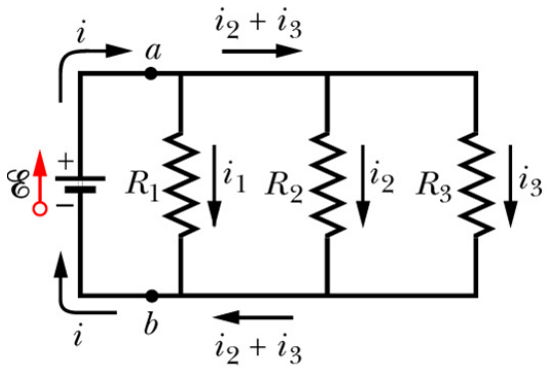
- **resistors in series**

$$R_{eq} = R_1 + R_2 + R_3$$



- **resistors in parallel**

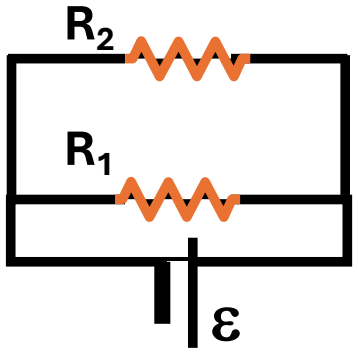
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



Note: these are opposite to capacitor combos

ConceptCheck Resistors in parallel

In this circuit, what is the voltage drop across R_2 ?



A. ε

B. ε / R_1

C. ε / R_2

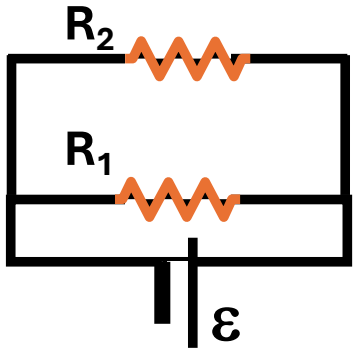
D. $\varepsilon R_1/(R_1+R_2)$

E. $\varepsilon R_2/(R_1+R_2)$

parallel resistors are directly connected to the same battery, same voltage ε

ConceptCheck Resistors in parallel

In this circuit, what is the current through R_2?



A. ε

B. ε / R_1

C. ε / R_2

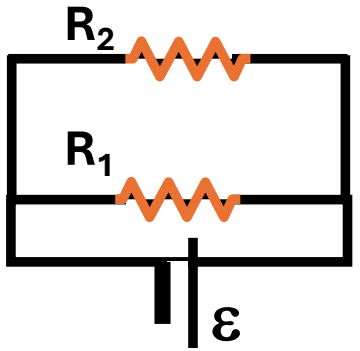
D. $\varepsilon R_1/(R_1+R_2)$

E. $\varepsilon R_2/(R_1+R_2)$

current is $i_2 = \varepsilon / R_2$

Try it! Resistors in parallel

What is the total current through the battery?



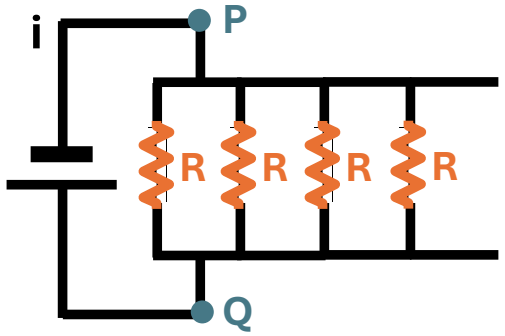
A. ε /(R_1+R_2)
B. ε /R_1
C. ε /R_2
D. ε R_1 R_2/(R_1+R_2)
E. ε (1/R_1+1/R_2)

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

so total current is i = ε /R_{eq} = i_1 + i_2

ConceptCheck Resistors in parallel

Points P and Q are connected to a battery of fixed voltage. As more resistors R are added to the parallel circuit, what happens to the total current in the circuit?



A. increases

B. remains the same

C. decreases

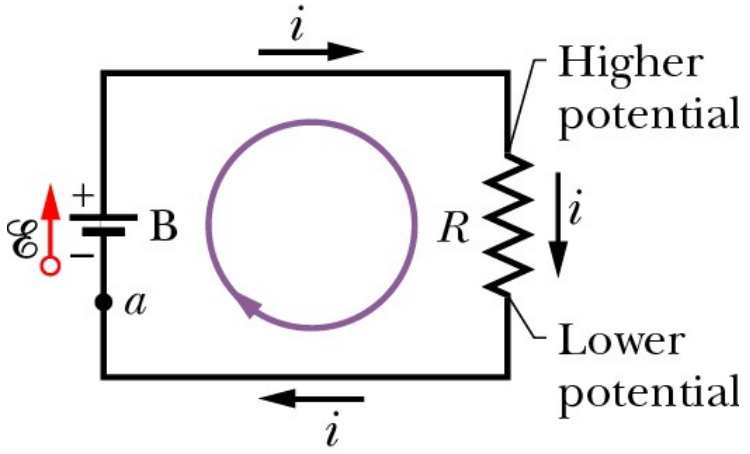
D. drops to zero

$$\frac{1}{R_{eq}} = \sum_j \frac{1}{R_j}$$

R_{eq} decreases when more R's are added, so total current increases

*** Daily quiz!**

Loop rule



- Start at point (a)
- As you pass the battery, add $\Delta V = \mathcal{E}$
- No voltage drop in wires (equipotential)
- As you go over the resistor, add $\Delta V = -iR$
  - (moving from high to low potential when we follow current direction)
- End up back at (a), so total voltage change is zero

$$\mathcal{E} - iR = 0$$

$$i = \mathcal{E}/R$$ Solve for current!

Rules for potential in circuits

Resistance Rule

moving through a resistor in the direction of the current flow the change in potential is $V = -iR$

EMF Rule

moving through an ideal emf source in the direction of the (external) current flow then the change in potential is $V = +\varepsilon$

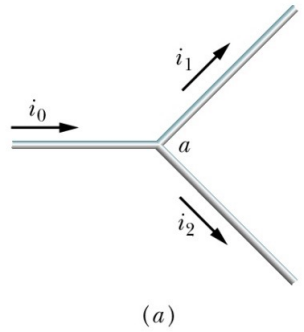
* These rules are not arbitrary! They are backed up by physical principles. If you know the principles, it will help you use the rules correctly.

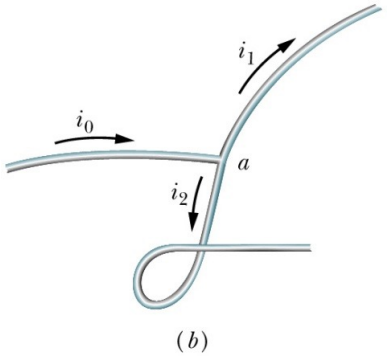
Junction Rule

- When a circuit splits into two paths, charge must be conserved between all the paths

- The sum of all currents entering a junction must be equal to the sum of all currents leaving the junction.

$$i_{in} = i_{out}$$



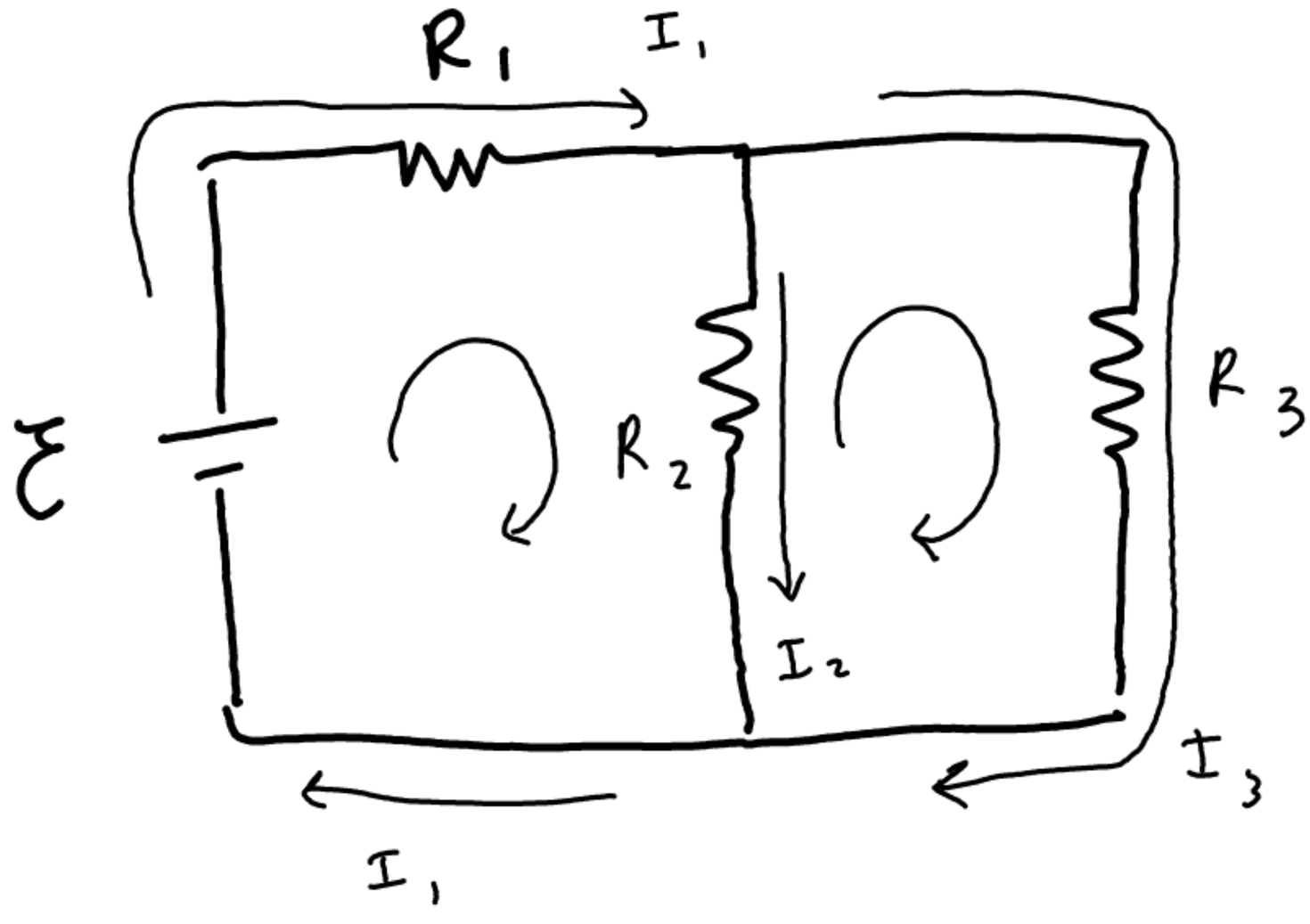


$$i_0 = i_1 + i_2$$

Process:

1. define loops
2. label currents in each branch
3. write Loop rule for voltages $\sum_{loop} V = 0$
4. write junction rule for currents $I_{in} = I_{out}$
5. solve!

Find the current through each resistor:



1. draw loops

2. draw currents

3. loop rule

1) $\mathcal{E} - I_1 R_1 - I_2 R_2 = 0$

2) $-I_3 R_3 + I_2 R_2 = 0 \longrightarrow I_3 = \dfrac{I_2 R_2}{R_3}$

4. junction rule $I_1 = I_2 + I_3$

rewrite eqn 1: $\mathcal{E} - (I_2 + I_3) R_1 - I_2 R_2 = 0$

$$\mathcal{E} - I_2 (R_1 + R_2) - I_3 R_1 = 0$$

$$\mathcal{E} - I_2 (R_1 + R_2) - \frac{I_2 R_2}{R_3} R_1 = 0$$

$$I_2 = \mathcal{E} \cdot \left(\frac{R_1 R_2}{R_3} + R_1 + R_2 \right)^{-1}$$

$$I_2 = \varepsilon \cdot \left(\frac{R_1 R_2}{R_3} + R_1 + R_2 \right)^{-1}$$

$$= \varepsilon \cdot \left(\frac{R_1 R_2}{R_3} + \frac{R_1 R_3}{R_3} + \frac{R_2 R_3}{R_3} \right)^{-1}$$

$$I_2 = \frac{\varepsilon R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}$$

$$I_3 = \frac{I_2 R_2}{R_3} = \frac{\varepsilon R_2}{R_1 R_3 + R_2 R_3 + R_1 R_2}$$

$$I_1 = I_2 + I_3 = \frac{\varepsilon (R_2 + R_3)}{R_1 R_3 + R_2 R_3 + R_1 R_2}$$