

Lecture 17: Circuits

- Review Junction law + Loop law
- Resistors in series and parallel
- Example
- Measurement

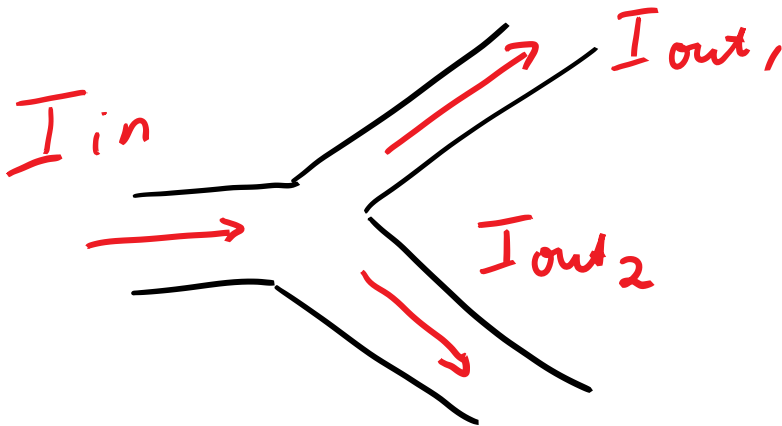
Kirchhoff's Laws: Junction Law

Lecture 14:

Current is the same at all points in a current-carrying wire.

Current is not “used up”. Charge cannot be created or destroyed.

“What goes in must come out”.



$$\sum I_{in} = \sum I_{out}$$

Kirchhoff's Laws: Loop Law

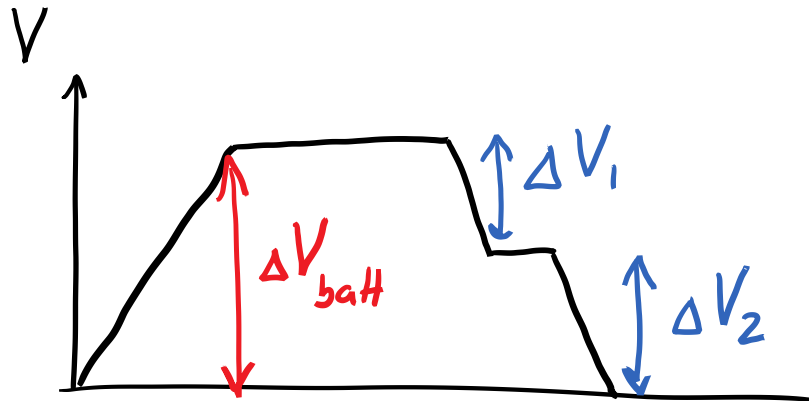
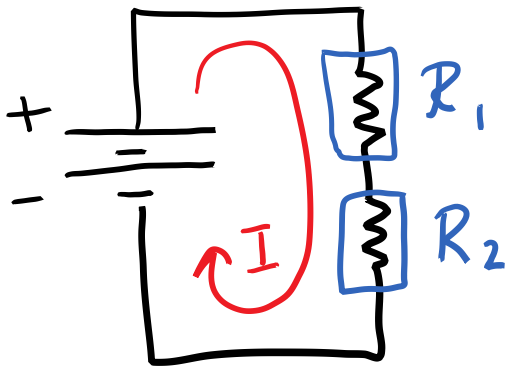
Potential energy depends on position.

If we come back to the same point, we come back to the same value of potential energy.

For closed loop: $\Delta U_{el} = 0$

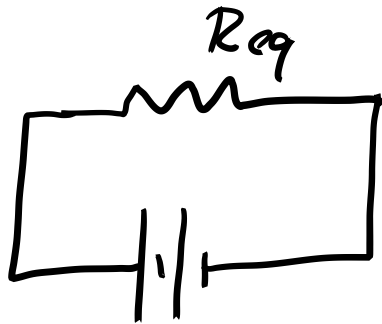
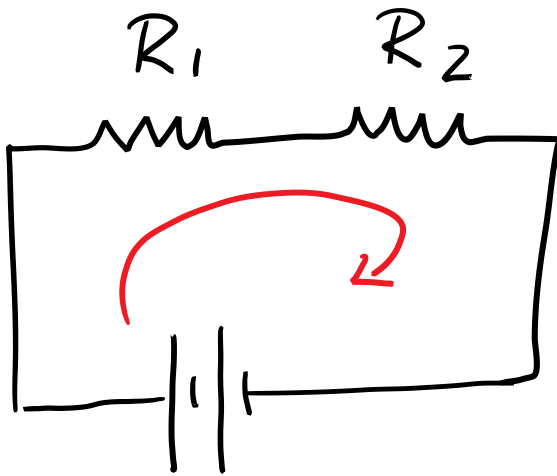
Because $V = U/q$: $\Delta V = 0$

$$\Delta V_{loop} = \sum_i \Delta V_i = 0$$



Resistors in series

same current



Loop rule :

$$+\varepsilon - IR_1 - IR_2 = 0$$

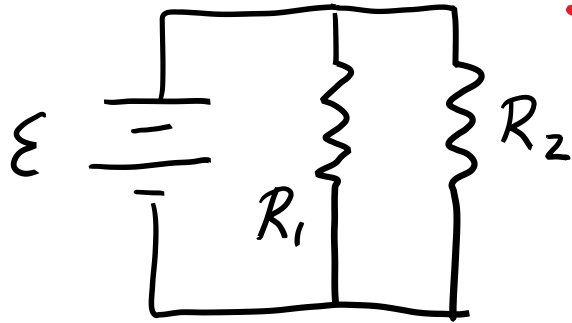
$$I = \frac{\varepsilon}{R_1 + R_2} = \frac{\varepsilon}{R_{eq}}$$

$$R_{eq} = \sum_i R_i$$

It is harder for current to go through a series of resistors
 $R_{eq} > R_i$

⚠ Battery provides fixed voltage, not fixed current

Resistors in parallel



same ΔV

$$I_{\text{tot}} = I_1 + I_2$$

$$I_{\text{tot}} = \frac{\mathcal{E}}{R_1} + \frac{\mathcal{E}}{R_2} = \mathcal{E} \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

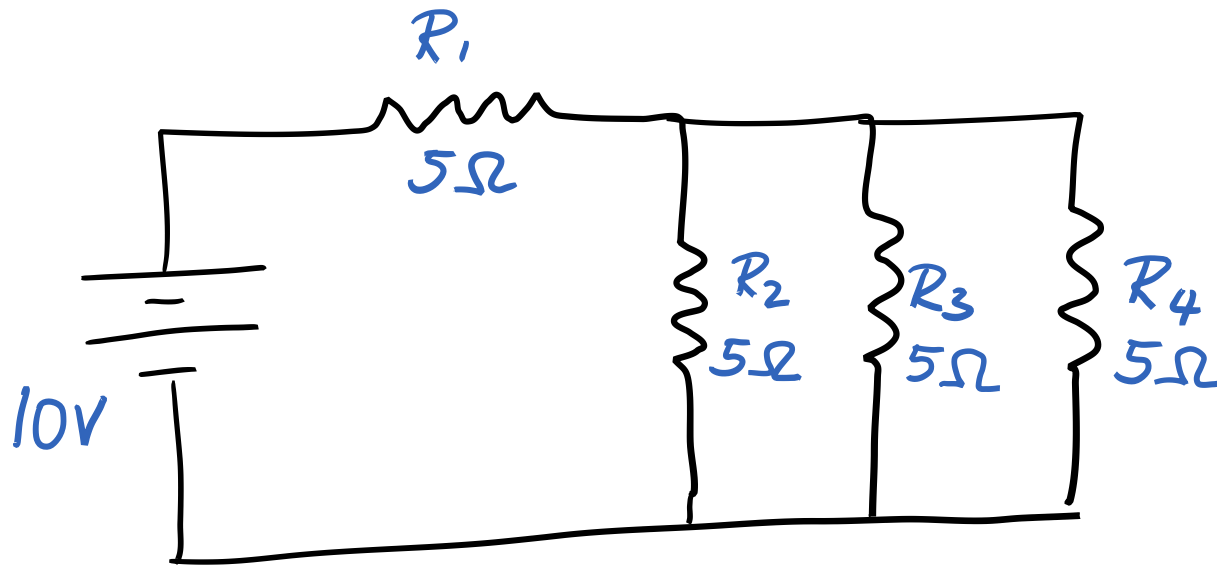
$$\frac{1}{R_{\text{eq}}} = \sum_i \frac{1}{R_i}$$

$$R_{\text{eq}} = \left(\sum_i \frac{1}{R_i} \right)^{-1}$$

It is easier for the current to go through multiple parts $R_{\text{eq}} < R_i$

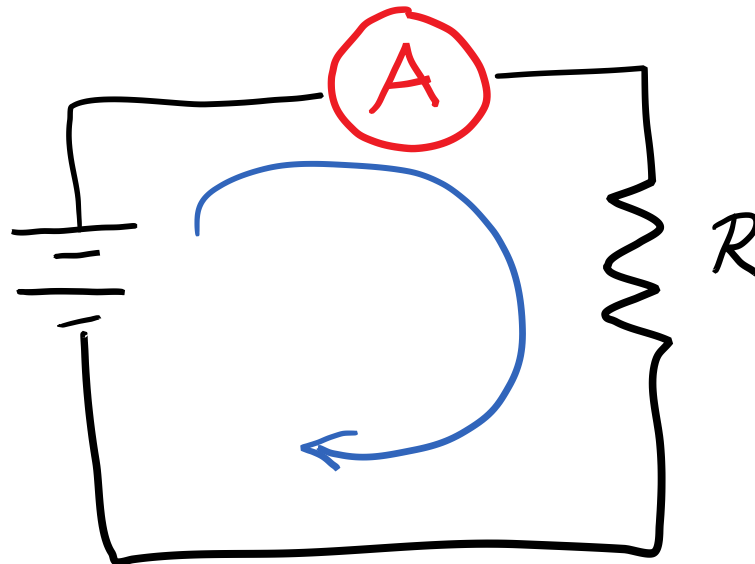
Practice

Example



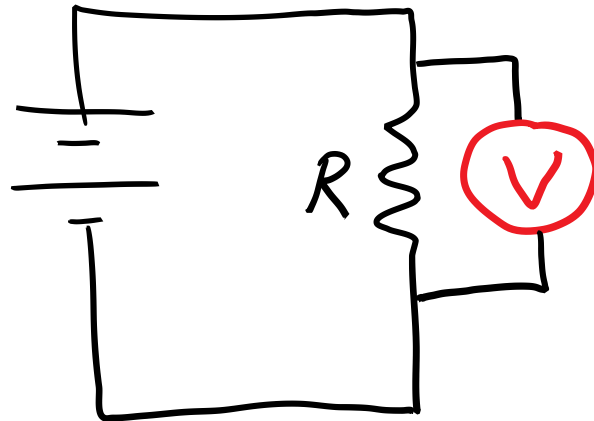
Measuring current

- Ammeter in series with the resistor (same current)
- Ideal Ammeter: zero resistance



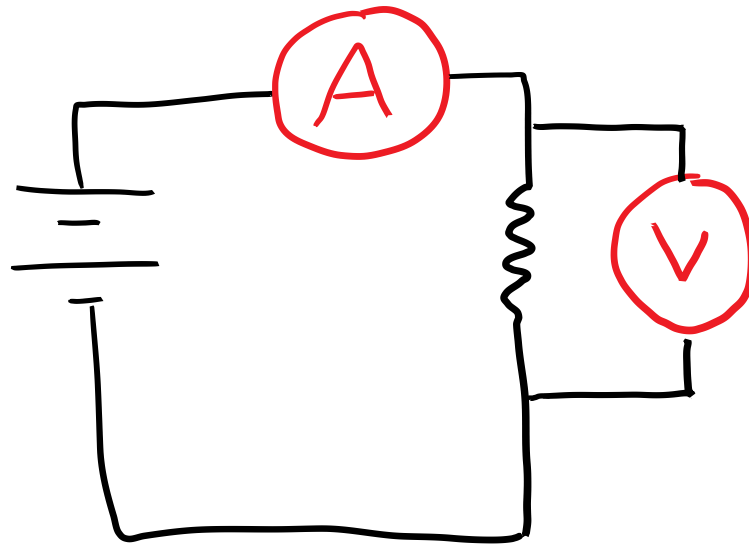
Measuring voltage

- Voltmeter in parallel with the resistor (same voltage)
- Ideal Voltmeter: infinite resistance

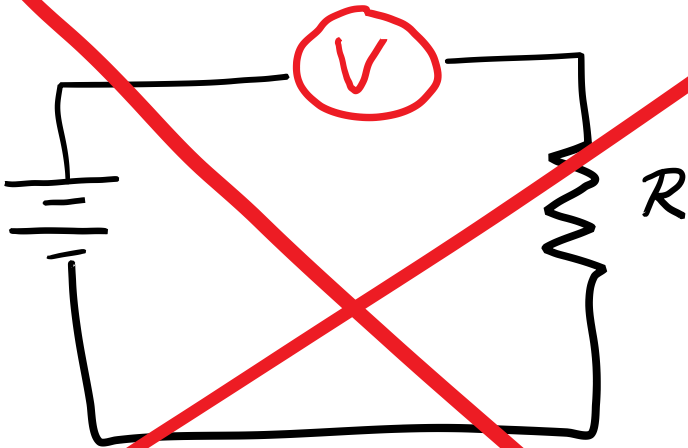


Measuring current and voltage simultaneously

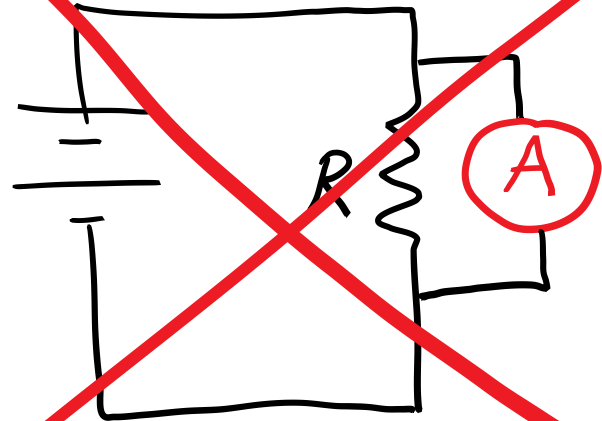
- Voltmeter in parallel with the resistor (same voltage)
- Ammeter in series with the resistor (same current)



WRONG:



$R_v = \infty$
no current



$R_A = 0$
all current goes
through ammeter,
none through
resistor