SUMMARY

The goal of Chapter 31 has been to understand the fundamental physical principles that govern electric circuits.

GENERAL STRATEGY

MODEL Assume that wires and, where appropriate, batteries are ideal.

VISUALIZE Draw a circuit diagram. Label known and unknown quantities.

SOLVE The solution is based on Kirchhoff's laws.

- Reduce the circuit to the smallest possible number of equivalent resistors.
- Find the current and the potential difference.
- "Rebuild" the circuit to find I and ΔV for each resistor.

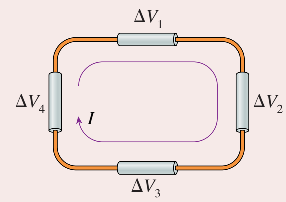
ASSESS Verify that

- The sum of potential differences across series resistors matches ΔV for the equivalent resistor.
- The sum of the currents through parallel resistors matches I for the equivalent resistor.

Kirchhoff's loop law

For a closed loop:

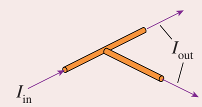
- Assign a direction to the current I.
- $\sum_i (\Delta V)_i = 0$



Kirchhoff's junction law

For a junction:

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



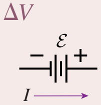
IMPORTANT CONCEPTS

Ohm's law

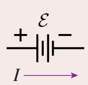
A potential difference ΔV between the ends of a conductor with resistance R creates a current

$$I = \frac{\Delta V}{R}$$

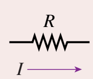
Signs of ΔV



$\Delta V_{bat} = +\mathcal{E}$



$\Delta V_{bat} = -\mathcal{E}$



$\Delta V_R = -IR$

The energy used by a circuit is supplied by the emf $\mathcal{E}$ of the battery through the energy transformations

$$E_{chem} \rightarrow U \rightarrow K \rightarrow E_{th}$$

The battery *supplies* energy at the rate

$$P_{bat} = I\mathcal{E}$$

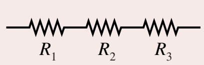
The resistors *dissipate* energy at the rate

$$P_R = I\Delta V_R = I^2R = \frac{(\Delta V_R)^2}{R}$$

APPLICATIONS

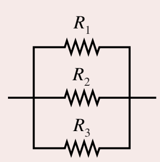
Series resistors

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



Parallel resistors

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\right)^{-1}$$



RC circuits

The discharge of a capacitor through a resistor satisfies:

$$Q = Q_0 e^{-t/\tau}$$

$$I = -\frac{dQ}{dt} = \frac{Q_0}{\tau}e^{-t/\tau} = I_0 e^{-t/\tau}$$

where $\tau = RC$ is the **time constant.**