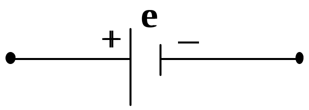
Summary of chapter 27

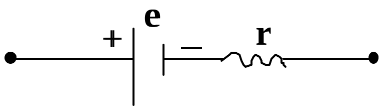
Prepared by Dr. A. Mekki

1. A battery is also called an electromotive force (emf).

   An ideal emf has no internal resistance r.



   A real emf has an internal resistance r.



2. Analyzing circuits:

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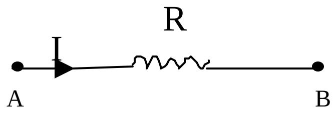

$$V_B - V_A = - I R < 0$$

As you move in the ***same direction as the current the potential drops*** (ΔV = V_B-V_A is **negative**).

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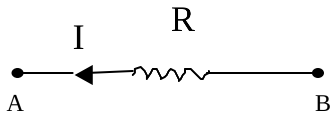

$$V_B - V_A = + I R > 0$$

As you move in the ***opposite direction of the current the potential increases*** (ΔV = V_B-V_A is **positive**).

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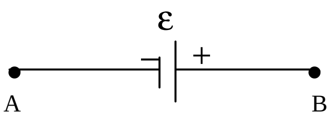

$$V_B - V_A = + e > 0$$

As you move across the power supply from ***– to +*** the ***potential increases*** (ΔV = V_B-V_A is **positive**).

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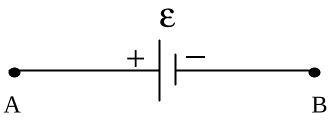


$$V_B - V_A = - e > 0$$

As you move across the power supply from ***+ to – the potential drops*** (ΔV is **negative**).

3. Suppose we have a battery of emf **e** and internal resistance **r** connected in an electrical circuit.
   - The rate of energy transferred from the emf to the charge carriers is **$P = I V$.**
   - The rate at which energy is dissipated in the internal resistance **r** of the battery is **$P = I^2 r$**.
   - The rate at which chemical energy inside the battery changes is **$P = I e$**.
   - Note: **$I V = I e - I^2 r$** **or** **$I e = I V + I^2 r$.**
   - If the emf is ideal then **$I e = I V$.**

4. Resistors

For a ***series combination*** of resistors, the equivalent resistor is:

$$R_{eq} = R_1 + R_2 + R_3 + \cdots\cdots\cdot$$

Note that the current through resistors is series is the same.

For a ***parallel combination*** of resistors, the equivalent resistor is:

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

Note that potential difference across each resistor is the same.

Kirchhoff's Law # 1:

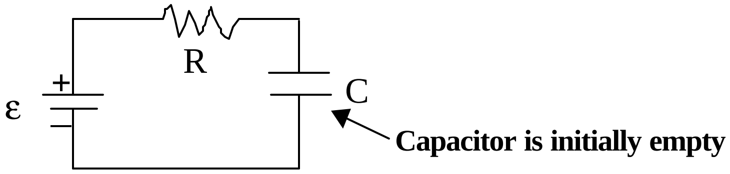
The sum of the currents at a junction must be equal to zero. This is the law of conservation of charge.

Kirchhoff's Law # 2:

The sum of the changes in potential around a loop must be equal to zero. This is the law of conservation of energy.

5. Capacitors

- When a battery is connected across an ***uncharged*** capacitor in a simple RC circuit, then the capacitor will charge up.



Capacitor is initially empty

The ***current*** in the circuit varies in time according to;

$$I(t) = \frac{\boldsymbol{e}}{R} e^{-\frac{t}{RC}} = \frac{\boldsymbol{e}}{R} e^{-\frac{t}{\boldsymbol{t}}}$$

The ***charge*** on the capacitor plate varies in time according to

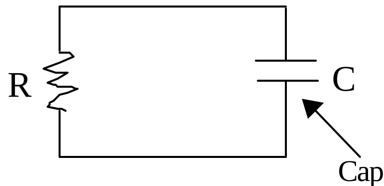
$$q(t) = C\boldsymbol{e}\,(1 - e^{-\frac{t}{RC}})$$

And the ***potential difference*** across the capacitor can be calculated from

$$V = \frac{q}{C} = \boldsymbol{e}(1 - e^{-\frac{t}{RC}})$$

Where ε is the potential difference (emf) across the battery in Volts, R is the resistance in the circuit in Ohms, and C is the capacitance in Farad. The product ***RC = t*** is called the ***time constant*** and has units of **time**.

- When a ***charged*** capacitor is connected across a resistance **R** then the capacitor will discharge into the resistance.



Capacitor has an initial charge q_o

The ***current*** in the circuit varies according to the expression:

$$I(t)=\frac{q_o}{RC}\,e^{-\frac{t}{RC}}$$

where q_o is the initial charge on the capacitor.

The ***charge*** on the plate of the capacitor varies in time according to the expression:

$$q(t)=q_o\,e^{-\frac{t}{RC}}$$

The potential difference across the capacitor varies in time according to the expression:

$$V=\frac{q}{C}=\frac{q_o}{C}\,e^{-\frac{t}{RC}}$$