Capacitance
Capacitors
Electric Current
Electric Current - Ohm's Law
Resistros in Series and Parallel

Electricity

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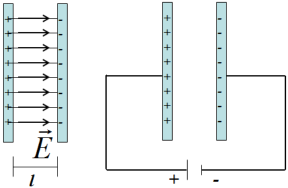
Capacitors

- - Capacitor:
  - is a device for storing electric charge;
- - consists of two conducting objects which do not touch;
- - typically two parallel plates separated by a distance l, and having an insulator between them;
- - when connected to a battery, the capacitor becomes charged;
- - the amount of charge acquired by each plate is: $Q = CdV$;



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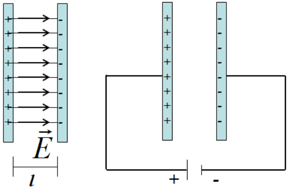

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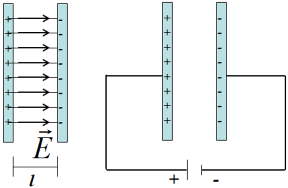

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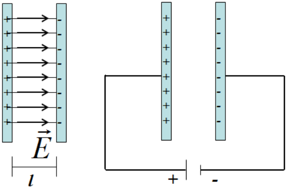

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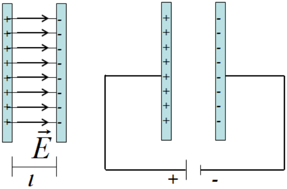

Capacitance

- \- for a parallel plate capacitor of area A we have:

$$E = \frac{Q}{\varepsilon_0 A}; dV = -\int_a^b \vec{E} d\vec{l};$$
$$C = \frac{Q}{dV} = \varepsilon_0 \frac{A}{l}; \quad (1)$$

- \- the capacitance of a single isolated conductor,
  \- for ex. a sphere of radius r,
  relative to V=0 at infinity is:

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r};$$
$$C = \frac{Q}{V} = 4\pi\varepsilon_0 r; \quad (2)$$

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- \- if the capacitors are connected in series
  \- a charge +Q flows from the batery to the left plate of C_1;
  \- and -Q flows to the right plate of C_3;
- \- if the regions between the capacitors are originally neutral,
  \- the net charge there must be zero;
- \- the +Q on C_1 attracts a charge of -Q on the opposite plate - and so on;
- \- a single capacitor that could replace these three in series without affecting the circuit will be:

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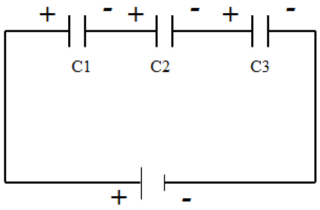
Capacitors in Series

$$\begin{aligned} Q = &\quad CV; V = V_1 + V_2 + V_1; \\ Q = &\quad C_i V_i; \frac{Q}{C} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}; \\ \frac{1}{C} = &\quad \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}; \end{aligned} \tag{3}$$



Capacitors in series

Capacitors in Parallel

- - if a battery of voltage V is connected to points *a*., and *b*., we get:

$$
\begin{aligned}
Q = &\quad Q_1 + Q_2 + Q_3 = C_1 V + C_2 V + C_3 V; \\
Q = &\quad CV = C_1 V + C_2 V + C_3 V; \\
C = &\quad C_1 + C_2 + C_3; \qquad (4)
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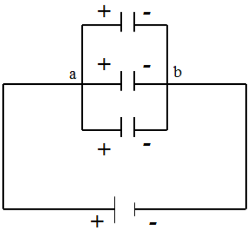

Capacitors in parallel

Capacitance
Capacitors

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Electric Current

- - the electric current in a wire is defined as
- - the net amount of charge that passes through it at a given point per unit time: $I = \frac{dQ}{dt}$;
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Electric Current

- - that is, the current which flows in a metal wire is proportional to the potential difference V applied to its ends;
- - it depends on the metal wire and is called resistance, R;
- - Ohm's law can be written and is known as: $I = \frac{V}{R}$;
- - the resistance of a uniform metal wire is directly proportional to its length L
- - and is equal by: $R = \rho \frac{L}{A}$;

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Electric Current and Electric Power

- - where ρ is the resistivity and depends on the material used and A is the cross section area;
- - the conductivity of a metal wire is given by: $\sigma = \frac{1}{\rho}$;
- - the energy transformed when an infinitesimal charge dq moves through a potential difference V is: $dU = dqV$;
- - if dt is the time required for an amount of charge dq to move through a potential difference V
- - then the power - that is, the rate energy transformed, is: $P = \frac{dU}{dt} = \frac{dq}{dt}V = IV = I(IR) = \frac{V^2}{R}$;

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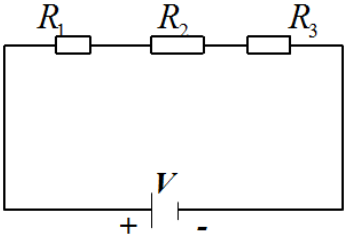
Electric Current - Ohm's Law

Resistros in Series and Parallel

Resistros in Series

- - when two or more resistors are connected so that the same current passes through each of them, (see fig.)
- - they are said to be connected in series;
- - if the voltage applied is V, then from Ohm's law for an equivalent single reistor R, we have: $R = \frac{V}{I}$;



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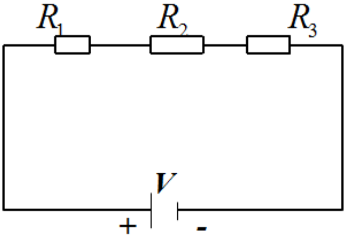

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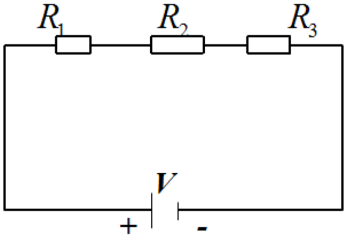

Resistors in Series

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- - because of conservation energy, the total voltage is equal to the sum of the voltages on each resistor;
- - that is: $V = V_1 + V_2 + V_3$;
  - where V_i is the potential difference across each resistor;
- - from where we get: $R = R_1 + R_2 + R_3$;

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- - at any junction point, the sum of all currents entering the junction, must equal the sum of all currents leaving the junction;
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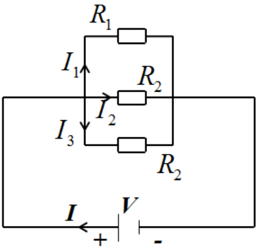

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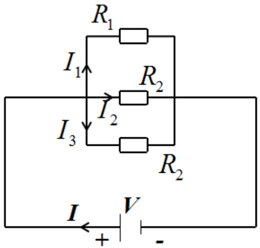

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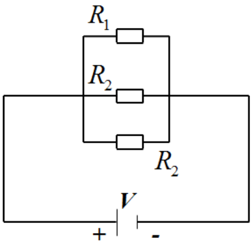

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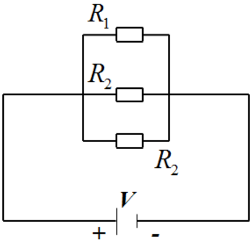

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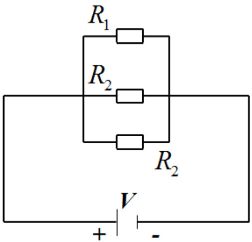

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