- Electric charges:

  Two types, positive and negative. Like charges repel, unlike charges attract.

  Charges conserve.

  The force between two point charges is governed by Coulomb's Law.

- Electric charges generate electric fields.

  Electric field exerts force on charges inside it.

  Charges inside an electric field has potential energy *U*. This potential energy equals the work the field does to the charge to move it outside of the field.

$$\mathbf{E} = \nabla U$$

  Electric field has energy with an energy density of $u_E = \frac{1}{2}\varepsilon_0 E^2$

  Electric field generated by point charge can be calculated using Coulomb's Law.

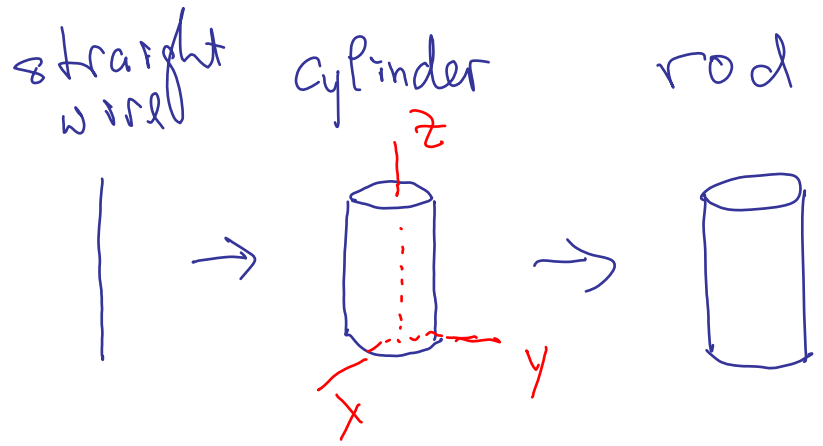
  Electric field generated in three special cases can be calculated using Gauss' Law.

  There is no electric field inside conductors: Faraday Cage.

- Gauss's Law: $\Phi_E = \frac{q}{\varepsilon_0}$

The three types of Gauss' Law problems

Geometry	Gaussian Surface
point, sphere, solid sphere	sphere
straight wire, cylinder, rod	cylinder along the z axis
plane, plate	cylinder



- Resistor and resistivity, energy dissipated by a resistor.

$$R = \frac{V}{I}, \quad R = \rho \frac{L}{A}, \quad \rho(t_2) = \rho(t_1)\left(1 + \alpha(t_2 - t_1)\right)$$

$$\mathcal{P} = VI = I^2 R = \frac{V^2}{R}$$

- Capacitor and capacitance, energy stored in a capacitor.

$$C \equiv \frac{Q}{V}, \quad \text{for parallel plate cap: } C = \frac{\varepsilon_0 A}{d}$$

$$\mathcal{P}_E = \frac{1}{2} C V^2, \quad u_E = \frac{1}{2} \varepsilon_0 \vec{E}^2$$

- Battery, internal resistant, efficiency and maximum delivered power.

emf, r (or R_{bat})

efficiency: $R_{load} / (R_{bat} + R_{load})$

max. power: when $R_{load} = R_{bat}$

- The connections of R and C in a circuit:

device	series	parallel
R	$R_{eff} = R_1 + R_2 + \cdots + R_n$	$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$
	$V_i \propto R_i$	$I_i \propto \frac{1}{R_i}$
	$P_i \propto R_i$	$P_i \propto \frac{1}{R_i}$
C	$\frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots \frac{1}{C_n}$	$C_{eff} = C_1 + C_2 + \cdots C_n$
	$V_i \propto \frac{1}{C_i}$	$I_i(Q_i) \propto C_i$

- RC circuits: charge and discharge.
- Kirchhoff's rules and the 4 steps to solve a problem.
  - Define loops and their directions,
  - Define branch currents and their directions.
  - Apply Kirchhoff's rules to construct equations.
  - Solve the equations.