Electromagnetism I

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So there are forces that govern how particles with electric charges interact. It's known as *electromagnetism*.

Total electric charge in an isolated system is always conserved.

$$\sum q_i = \sum q_f$$

Coulomb's Law

The magnitude of the electrostatic force of interaction between two point charges is directly proportional to the scalar multiplication of the magnitudes of charges and inversely proportional to the square of the distance between them.

$$\mathbf{F} = k_e \frac{q_1 q_2}{r^2} \quad where \;\; k_e = 8.987 \times 10^9 NM^2C^{-2}$$

Electric Field

An electric field is a vector field that associates to each point in space the Coulomb force experienced by a test charge. In the simplest case, the field is considered to be generated solely by a single source point charge. The strength and direction of the Coulomb force $\mathbf{F}$ on a test charge q_t depends on the electric field $\mathbf{E}$ that it finds itself in, such that $\mathbf{F} = q_t\mathbf{E}$. If the field is generated by a positive source point charge q, the direction of the electric field points along lines directed radially outwards from it, i.e. in the direction that a positive point test charge q_t would move if placed in the field. For a negative point source charge, the direction is radially inwards.

$$\mathbf{E} = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2} = \frac{\mathbf{F}}{q}$$

Electric field is the force per unit test charge:

$$E = \frac{F}{q}$$

Electric potential is the electric potential energy per unit charge:

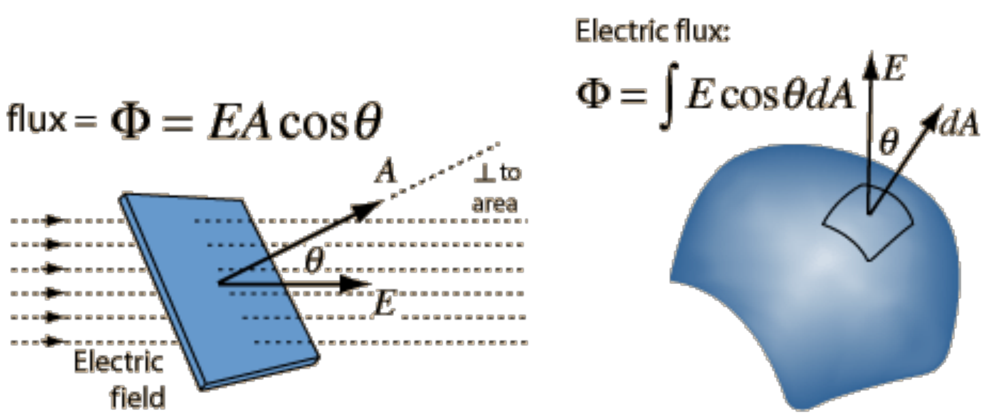
$$V = \frac{U}{q}$$

The Electric potential energy between two point charges is NOT a force!

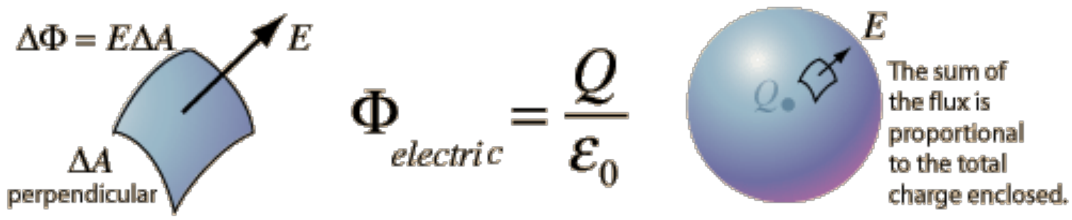
$$U = k\frac{q1q2}{r}$$

Gauss's Law

The concept of electric flux is useful in association with Gauss' law. The electric flux through a planar area is defined as the electric field times the component of the area perpendicular to the field. If the area is not planar, then the evaluation of the flux generally requires an area integral since the angle will be continually changing.



The total of the electric flux out of a closed surface is equal to the charge enclosed divided by the permittivity. The electric flux through an area is defined as the electric field multiplied by the area of the surface projected in a plane perpendicular to the field. Gauss's Law is a general law applying to any closed surface.

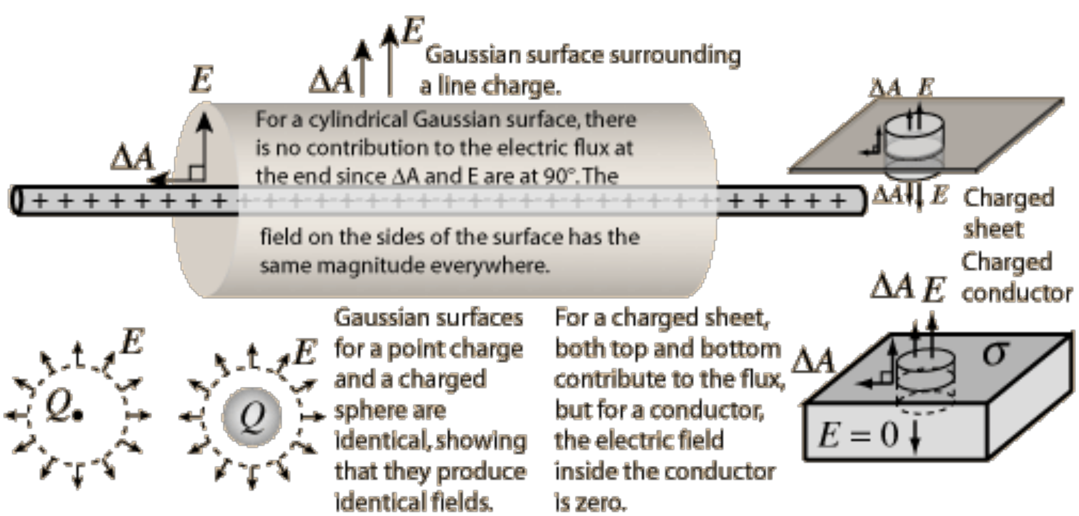


Gauss' Law in integral form

The area integral of the electric field over any closed surface is equal to the net charge enclosed in the surface divided by the permittivity of space. Gauss' law is a form of one of Maxwell's equations, the four fundamental equations for electricity and magnetism.

$$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q}{\epsilon_0}$$

Part of the power of Gauss' law in evaluating electric fields is that it applies to any surface. It is often convenient to construct an imaginary surface called a Gaussian surface to take advantage of the symmetry of the physical situation.



If the symmetry is such that you can find a surface on which the electric field is constant, then evaluating the electric flux can be done by just multiplying the value of the field times the area of the Gaussian surface.

Constants

$$k_e = 8.987 \times 10^9 NM^2C^{-2}$$

$$\epsilon_0 = 8.85418... \times 10^{-12} = 8.85 \times 10^{-12}\ \mathbf{F}/m$$