Acumen Tutoring™

Constants

Unit charge, $e = 1.602 \times 10^{-19}$ Coulomb

Electric permittivity of space, $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$

Coulomb's constant, $k = 1/(4\pi\varepsilon_0) = 9\times10^9\ Nm^2/C^2$ ← ε_0 is the permittivity of space

Magnetic permittivity of free space, $\mu_0 = 4\pi \times 10^{-7}$ M/A^2 = 1.26×10^{-6}

Mass of electron, $m_e = 9.11 \times 10^{-31}$ kg

Units

1 Amp = 1 C/s

Electric field: N/C, same as V/m

Basic equations for charges and electric fields

Force and field around a charge

Force between two charges: $\boldsymbol{F} = \dfrac{kqQ}{r^2}$

Field around a point charge: $\boldsymbol{E} = \dfrac{kQ}{r^2}$

Force on a charge in a field: $\boldsymbol{F} = \boldsymbol{E}q$

Electric Potential (Voltage)

Note voltage is a scalar; it *does* have a sign, though.

The potential at a point is equal to the work done moving a charge from ∞ to that point.

$V = \dfrac{kq}{r}$ $V = \dfrac{U}{q}$ ← U is the potential energy at the point in question

Potential difference between two points

$\Delta V = -E\Delta r$ Δr = distance between points

$E = -\dfrac{dV}{dr}$ Just the previous equation rearranged

$V = -\int E\, dr$

Field around a dipole

E field a distance *z* from a dipole with charges +q and –q that are separated by a distance *d* is:

$E = \dfrac{p}{4\pi\varepsilon_0 z^3}$ The dipole moment, $p = qd$

$z >> d$

Work and potential energy

Potential Energy between two charges:

$U = \dfrac{kqQ}{r}$

Work, *W*, in moving a charge a distance *d* in a constant electic field

$W = Eqd$

In a variable field,

$dW = q\int E(x)dx$ ← Note *E* is a function of *x*

Electric flux, Φ

Predicts rate of flow of electric field, *Electric flux*, Φ_E, through a given area. This is a scalar value, though it does have a sign.

Uniform E-field: $\Phi_E = \mathbf{E} \cdot \mathbf{A} = EA\cos\theta$ ← The bold-face quantities are vectors

E = electric field A = surface area θ = angle of field to surface's normal

Non-uniform E-field: $\Phi_E = \iint_S \mathbf{E} \cdot d\mathbf{A}$ ← Integrating to get entire surface area

Gauss's Law

Total electric flux through a surface enclosing a charge:

$$\Phi_E = \frac{Q}{\varepsilon}$$

$$EA\cos\theta = \frac{Q}{\varepsilon}$$

If the field is perpedicular to the surface: $EA = \frac{Q}{\varepsilon}$