electric field and electric force

q_s
"electric charge"

scalar
unit=C

If $q_s>0$, then dir $\vec{E}$ is away from q_s.
If $q_s<0$, then dir $\vec{E}$ is toward q_s.

→

Gauss's Law: $\oint \vec{E} \bullet d\vec{A} = \dfrac{\text{net } q_{\text{enclosed}}}{\varepsilon_0}$

For a uniform $\vec{E}$ which is perpendicular to the Gaussian surface: $\dot{E}A = \dfrac{|\text{net } q_{\text{enclosed}}|}{\varepsilon_0}$

Point source: $\dot{E} = \dfrac{k\dot{q}_s}{r^2}$ (Coulomb's Law)

Spherical symmetry:

Outside: $\dot{E} = \dfrac{\dot{Q}}{4\pi\varepsilon_0 r^2} = \dfrac{k\dot{Q}}{r^2}$

Inside uniformly charged sphere: $\dot{E} = \dfrac{k\dot{Q}r}{R^3}$

Inside hollow sphere: $E=0$

Line symmetry: Outside: $\dot{E} = \dfrac{\dot{\lambda}}{2\pi\varepsilon_0 r}$

Inside hollow pipe: $E=0$

Plane symmetry: Outside: $\dot{E} = \dfrac{\dot{\sigma}}{2\varepsilon_0}$

$\vec{E}$ at a point in space
"electric field"

vector; unit = N/C

The $\vec{E}$ at a point in space indicates what the $\vec{F}$ would be on a +1C q_0 at that point in space.

If $q_0>0$, then dir $\vec{E}$ = dir $\vec{F}$.
If $q_0<0$, then dir $\vec{E}$ is opposite to dir $\vec{F}$.

→

$\dot{F} = \dot{E}\dot{q}_0$

For point charges or nonoverlapping spherically symmetrical charge distributions:

$\dot{F} = \dfrac{k\dot{q}_1\dot{q}_2}{r^2}$ (Coulomb's Law)

$\vec{F}$ on q_0
"electric force"

vector
unit=N

$k = \dfrac{1}{4\pi\varepsilon_0}$, $\varepsilon_0 = \dfrac{1}{4\pi k}$. Units for λ are C/m. Units for σ are C/m^2. Units for ρ (not shown in chart) are C/m^3.

electric potential energy and electric potential

q_s
"electric charge"

scalar
unit=C

→

$$V = \frac{kq_s}{r}$$

This formula works for a point source, or outside a spherically symmetric charge distribution.

→

V at a point in space
"electric potential"

scalar; unit=volt=J/C

The *V* at a point in space indicates what the *U* would be for a +1C q_0 at that point in space; i.e., the *V* at a point in space indicates how much work it would take to move a +1C q_0 from ∞ to that point in space.

For $q_0>0$, *V* is like "height".
For $q_0<0$, *V* is like "depth".

→

$$U = Vq_0$$

For point charges or nonoverlapping spherically symmetric charge distributions:

$$U = \frac{kq_1q_2}{r}$$

→

U of q_0,q_s system
"electric potential energy"

scalar; unit=J

The *U* of a system of charges indicates how much work it would take to move the charges from ∞ to their present positions.

electric potential difference and change in electric potential energy

q_s
"electric charge"

scalar
unit=C

→ $\vec{E}$ →

$$\Delta V_{AB} = -\int_A^B \vec{E} \bullet d\vec{r}$$

$\vec{E}$ points from high *V* to low *V*, indicating the sign of ΔV.

For constant $\vec{E}$: $\Delta \dot{V} = \dot{E}_{\parallel} \cdot \Delta \dot{r}$

For point sources, or outside spherically symmetric charge distributions:

$$\Delta V_{AB} = \frac{kq_s}{r_B} - \frac{kq_s}{r_A}$$

ΔV between two points in space
"electric potential difference", "voltage"
The symbol "*V*" is often used to mean "ΔV".

scalar; unit=volt=J/C

The ΔV between two points in space indicates what the ΔU would be for a +1C q_0 moving between those two points in space;
i.e., the ΔV between two points in space indicates how much work it would take to move a +1C q_0 between those two points in space.

For $q_0>0$, ΔV is like "change in height".
For $q_0<0$, ΔV is like "change in depth".

→

$$\Delta U = \Delta V \cdot q_0$$

ΔU of q_0,q_s system
"change in electric potential energy"

scalar; unit=J

The ΔU of a system of charges indicates how much work it took to move the charges from their previous positions to their present positions.