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Electric field

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Description

- Electric field - the physical state of space in the vicinity of stationary and unchanging electric charges, within which the action of mechanical force on other electric charges introduced into that space is registered;
- the most common description of the electric field uses vector called simply the electric field, common symbol **E**, its intensity SI unit is volt-per-metre [V/m];
- field of a point charge *q* at a distance *r*:

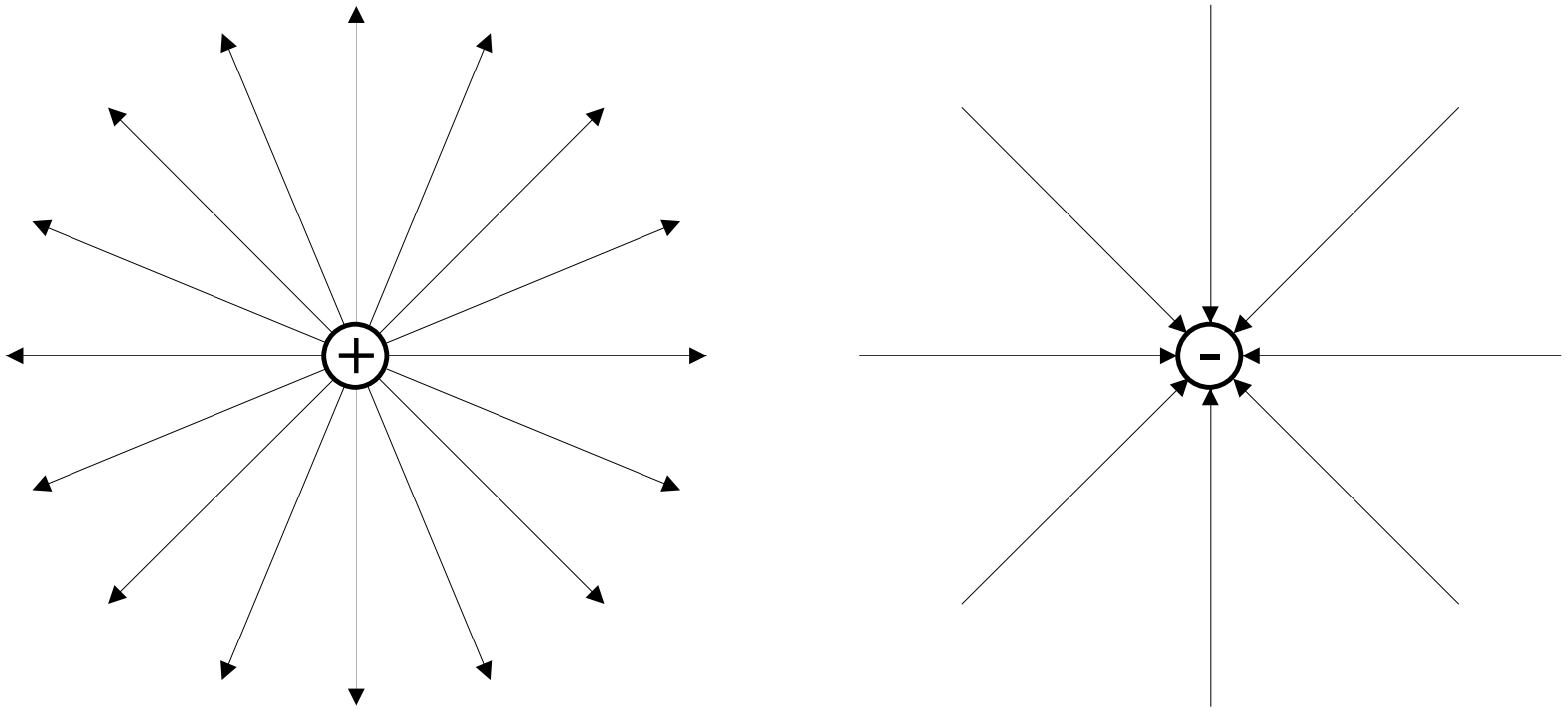
$$\mathbf{E} = \frac{q}{4\pi\varepsilon r^2}\mathbf{r}_0$$

- the direction of the field is from the positive charge to the surrounding space or from the surrounding space to the negative charge.

Filed lines

- Field lines are a graphical visualization of electric field vectors. These are curved lines where the tangent at each point coincides with the direction of the field vector;
- field lines are intermittent, they spring from positive charges and sink into negative charges, the positive charge is the source, and the negative is the sink of the field;
- field lines cannot intersect;
- the density of field lines is used as a visual indicator of its intensity.

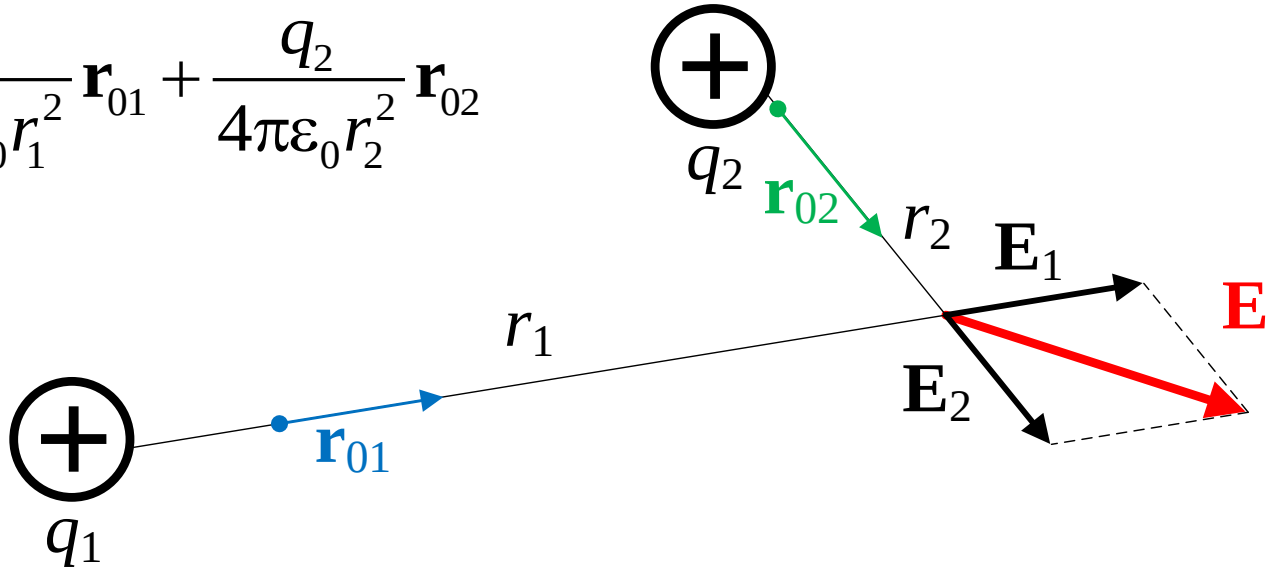
Filed lines – a poit charge exapmle



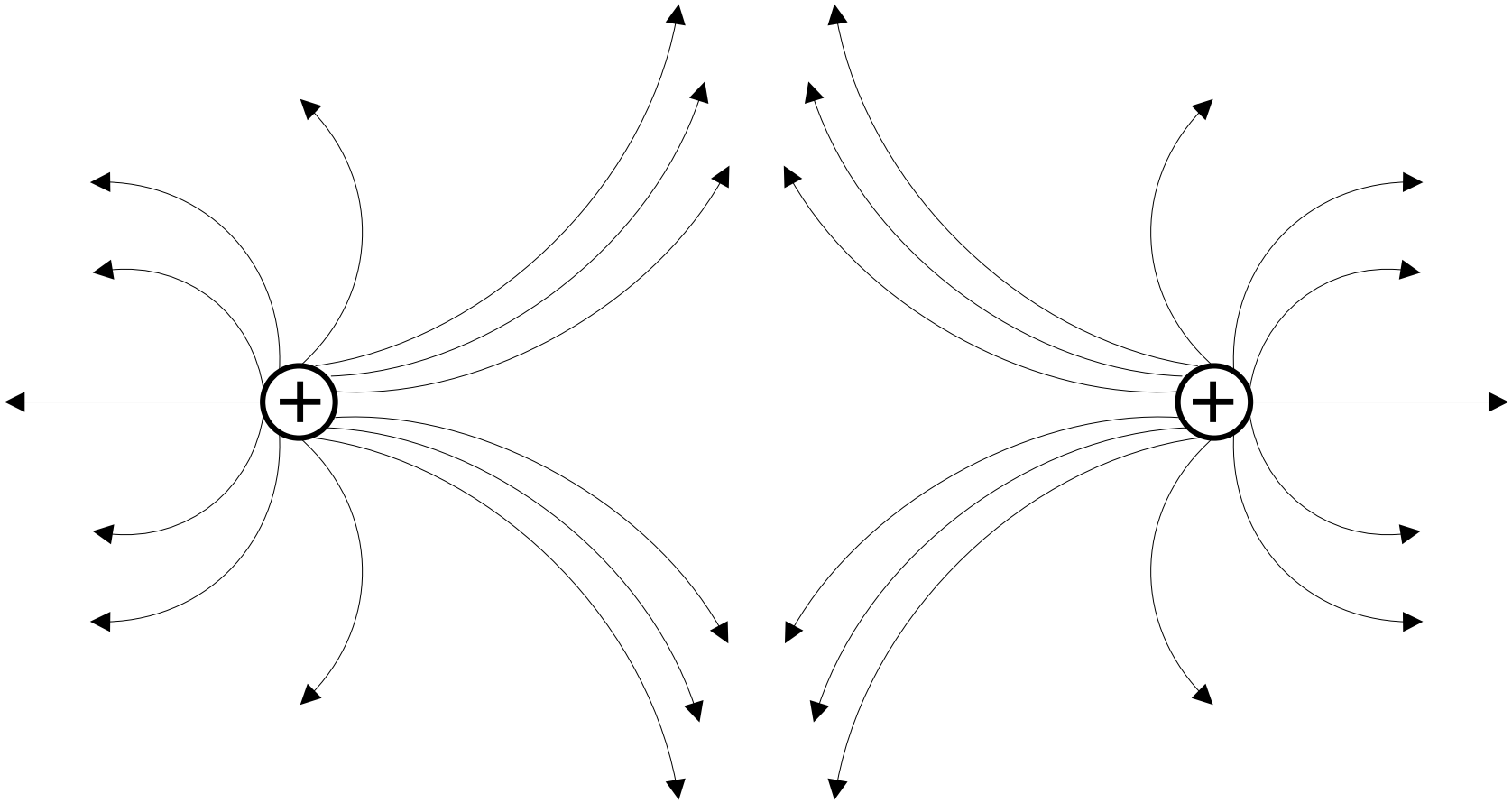
Field additivity

- If there are electric charges q_1 and q_2, in space which create electrostatic fields $\mathbf{E}_1$ and $\mathbf{E}_2$, then the total strength of the field $\mathbf{E}$ at an arbitrary point in space is equal to the vector sum of the fields of individual charges,

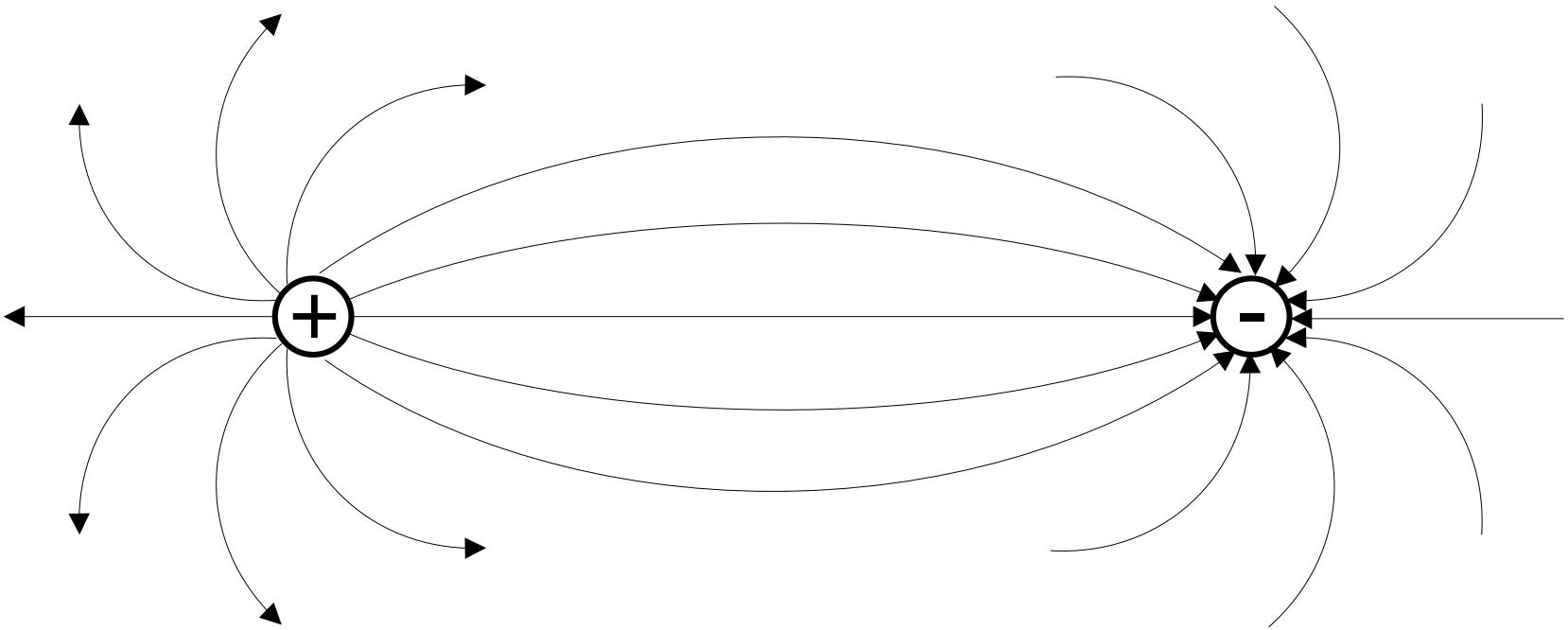
$$\mathbf{E} = \mathbf{E}_1 + \mathbf{E}_2 = \frac{q_1}{4\pi\varepsilon_0 r_1^2}\mathbf{r}_{01} + \frac{q_2}{4\pi\varepsilon_0 r_2^2}\mathbf{r}_{02}$$



Field lines – same sign point charges

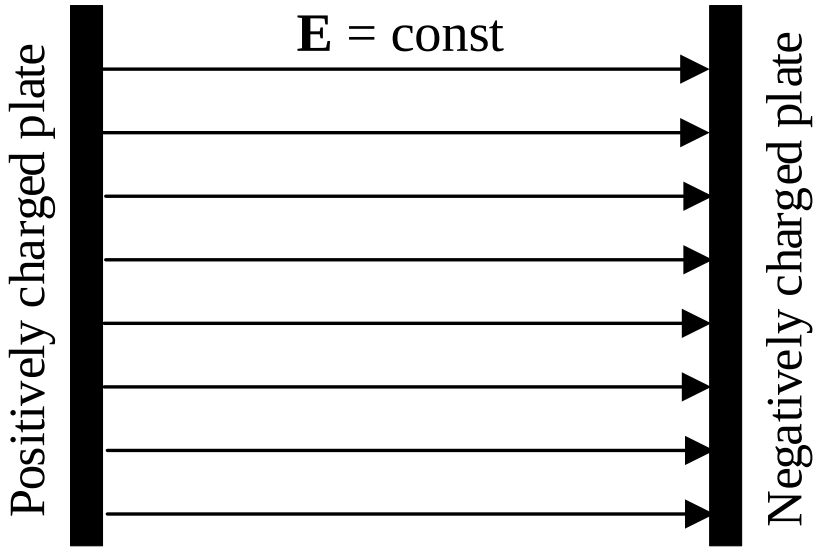


Field lines – opposite sign point charges



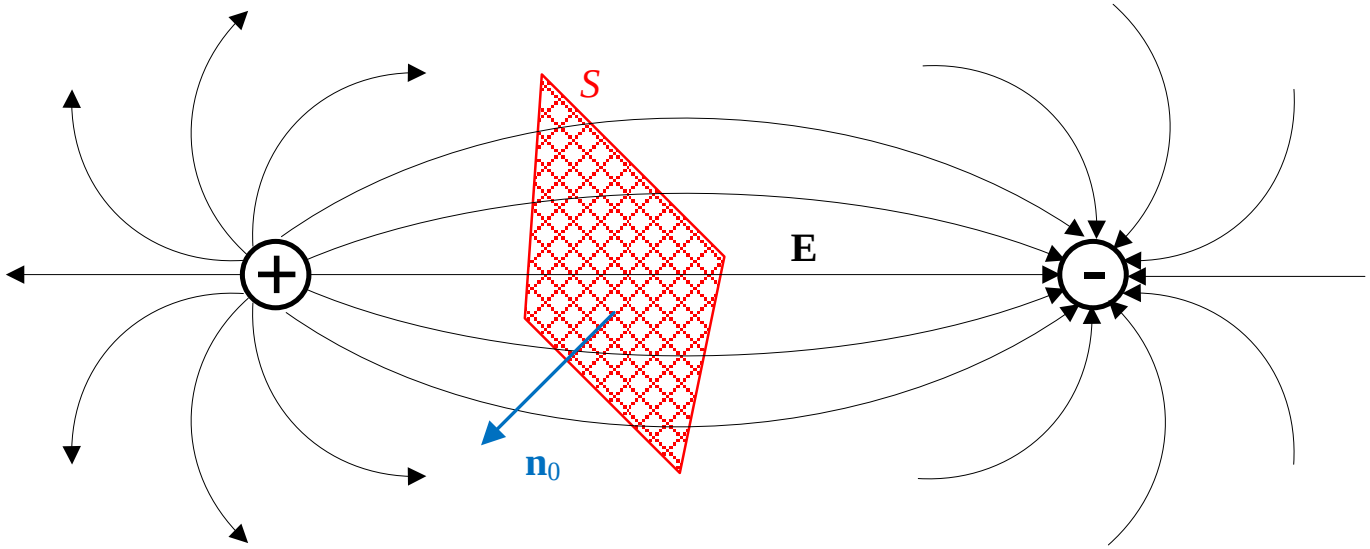
Homogeneous field

- A field in which the field vector E is constant is a homogeneous electric field;
- homogeneous field lines are parallel, have equal length and density.



Electric flux

- Electric flux is total electric field that crosses a given surface.



Gauss's flux theorem

- The flux of the electric field out of an arbitrary closed surface is proportional to the electric charge enclosed by the surface, irrespective of how that charge is distributed.;
- If the field is homogeneous with intensity E in vacuum and the surface S is perpendicular to the field, the theorem is mathematically interpreted by the formula:

$$E \cdot S = \frac{\sum Q}{\varepsilon_0}$$

Electric potential

- Electric potential is the amount of work/energy needed per unit of electric charge to move the charge from a reference point to a specific point in an electric field;
- common symbol is *V*, where SI unit is volt [V];
- the electric potential, is only defined up to an additive constant: one must arbitrarily choose a position where the potential energy and the electric potential are zero;
- Potential of poit charge at distance *r* : $V = E \cdot r = \frac{q}{4\pi\varepsilon r}$
- Potential additivity: $V = \sum_{i=1}^{n} \frac{q_i}{4\pi\varepsilon r_i}$

Electric voltage

- Voltage, also known as (electrical) potential difference, electric pressure, or electric tension, is the difference in electric potential between two points;
- it is important that both potentials are calculated to the same additive constant;
- Voltage in point charge created filed:

$$U_{AB} = V_A - V_B = \frac{q}{4\pi\varepsilon}\left(\frac{1}{r_A} - \frac{1}{r_B}\right)$$

- conservative nature of the electric filed:

$$U_{AC} = V_A - V_C = (V_A - V_B) + (V_B - V_C) = U_{AB} + U_{BC} = U_{AB} - U_{CB}$$