Physics 102

Lecture 7. Wed. Sept. 22, 2004.

- Electric potential V. — scalar!

$$V = \frac{U}{q}. \qquad U \text{ — potential energy.}$$

unit : Volt = J/C.

- Relation with $\vec{E}$:

① Direction of $\vec{E} \perp$ equipotential lines.

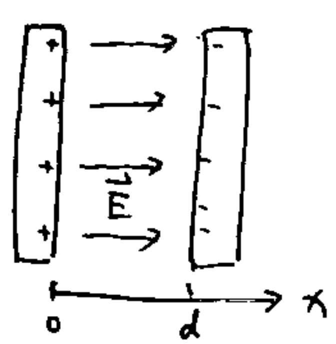
② . $E = -\frac{\Delta V}{\Delta s}$ when Δs is along $\vec{E}$-line.

In general: $E_x = -\frac{\Delta V}{\Delta x}$

$E_y = -\frac{\Delta V}{\Delta y}$

$E_z = -\frac{\Delta V}{\Delta z}$.

- e.g. Electric potential in a parallel-plate capacitor.



$\vec{E} = E\,\hat{x} = E_x\,\hat{x}$.

from Gauss's Law: $E = \frac{\sigma}{\varepsilon_0}$ (e.g. 19-3)

σ — surface charge density.

$\left(\sigma = \frac{q}{A}\right)$

Then, along x-axis : $\Delta s = \Delta x$.

$$E = E_x = -\frac{\Delta V}{\Delta x} = \frac{\sigma}{\varepsilon_0} \quad \text{(constant)}$$

$$\Delta V = -\frac{\sigma}{\varepsilon_0}\cdot \Delta x$$

$$V_+ - V_- = -\frac{\sigma}{\varepsilon_0}(0-d)$$ Potential difference $\equiv$ Voltage.

$$\boxed{V = \frac{\sigma d}{\varepsilon_0}.}$$ Voltage across a parallel-plate capacitor.

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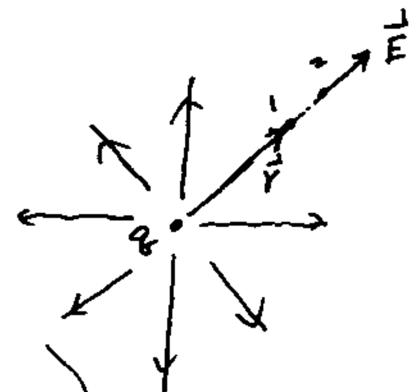
e.g. electric potential of a point charge.

$\vec{E} \parallel \vec{r}$ always.

along a radius (along $\vec{E}$-line).

from point 1 to point 2.



$$E = -\frac{\Delta V}{\Delta r}$$ (only because $\vec{r}$ is along $\vec{E}$!)

$$= -\frac{V_2 - V_1}{r_2 - r_1}$$

Then:

$$\Delta V = -E\cdot\Delta r, \quad dV = -E\,dr, \quad E = -\frac{dV}{dr}.$$

$$V = -\int E\,dr. \qquad E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}.$$

$$= -\int \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r^2}\,dr$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r} + C$$

Choose $V=0$ at ∞ (We often do this for finite charge distributions)

Then $C=0$.

$$\boxed{V = \frac{q}{4\pi\varepsilon_0 r} = \frac{kq}{r}.}$$

electric potential of a point charge assuming $V(\infty)=0$.

- superposition principle of electric potential.

(Now it's algebraic sum!)
NOT vector sum.

V — scalar!