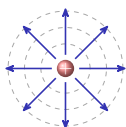


Electric Potential

AP Physics C: E&M • Unit 9

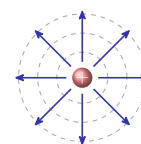
AP Physics C: E&M



Electric Potential

What we will cover

- 1 Electric potential energy
- 2 Electric potential (voltage)
- 3 Potential and field
- 4 Conservation of electric energy



1

Potential energy

Electric Potential
└ Potential energy

Electric potential energy

Electric potential energy 电势能 is the work to assemble charges from infinity:

A pair, and a system

$$U = k \frac{q_1 q_2}{r}, \quad U_{\text{tot}} = k \sum_{\text{pairs}} \frac{q_i q_j}{r_{ij}}$$

Like charges: $U > 0$ (fly apart). Unlike: $U < 0$ (a well). Note r , not r^2 ; $W = -\Delta U$.



Power lines

2

Potential

Electric Potential
└ Potential

Electric potential (voltage)

Electric potential 电势 is energy per unit charge – a scalar:

Point charge, sum, integral

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

$$V = k \sum_i \frac{q_i}{r_i} = k \int \frac{dq}{r}$$

Adding potentials is **easy** – just add numbers with signs, no vectors.

Worked example

+3 nC and -3 nC, each 2 m away:

$$V = k \left(\frac{+3}{2} + \frac{-3}{2} \right) \times 10^{-9} = 0$$

Yet $\vec{E} \neq 0$ there – V and $\vec{E}$ tell different stories.

Potential and field

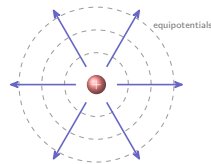
Field and potential are linked by calculus:

Integrate, or take the gradient

$$V = - \int \vec{E} \cdot d\vec{l}, \quad \vec{E} = -\nabla V$$

In 1-D, $E_x = -\frac{dV}{dx}$; the field points downhill in V .

Equipotentials 等势面 are always perpendicular to field lines; no work moving along one.



3 Conservation

Conservation of electric energy

Moving a charge through a **potential difference** 电势差 does work:

Work and kinetic energy

$$W = q\Delta V, \quad \Delta K = q\Delta V$$

- a + charge speeds up moving to lower V
- 1 eV 电子伏特 = 1.6×10^{-19} J (an energy)

Worked example

An electron through 200 V:

$$\Delta K = 200 \text{ eV} = 3.2 \times 10^{-17} \text{ J}$$

$$v = \sqrt{\frac{2\Delta K}{m}} \approx 8.4 \times 10^6 \text{ m/s}$$

4 Recap

Unit 9 – key takeaways

1 Energy

$U = kq_1q_2/r$; sum over distinct pairs; $W = -\Delta U$

2 Potential

$V = kq/r$, a scalar; $V = k \int dq/r$ for distributions

3 Field link

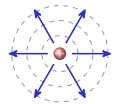
$V = - \int \vec{E} \cdot d\vec{l}$, $\vec{E} = -\nabla V$; equipotentials $\perp$ field

4 Conservation

$\Delta K = q\Delta V$; energy in electron volts

Check yourself

- Is electric potential a scalar or a vector?
- How do you get the field from the potential?
- How much work moves a charge along an equipotential?
- An electron falls through 50 V – how much energy in eV?



Answers 1. a scalar 2. $\vec{E} = -\nabla V$ 3. zero 4. 50 eV