

Topic 3 Summary

Electric potential

12 adv

Term 1

23-24



Electric potential Topic 3

Electric potential energy: is the energy stored in a system of electric charges.

* for a system of 2 electric charges

$$U = \frac{Kq_1q_2}{r}$$

U: Joules (J)

$$K = 9 \times 10^9$$

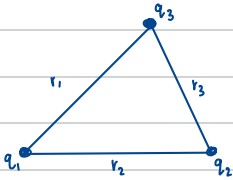


• Another unit for energy is eV (electron volt)

$$J \longrightarrow eV$$

divide by 1.6×10^{-19}

* for a 3 point charges system



$$U = \frac{Kq_1q_2}{r_2} + \frac{Kq_2q_3}{r_3} + \frac{Kq_1q_3}{r_1}$$

Electric potential or voltage at a point in space.

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

measured in volts

* Voltage at a point in space due to a point charge at a distance r .

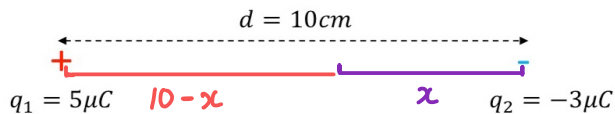
$$V = \frac{Kq}{r}$$

* For a system of more than 2 electric charges, we use the method of superposition.

$$V = \sum \frac{kq}{r}$$

* For a system of 3 charges :

$$V = \frac{kq_1}{r_1} + \frac{kq_2}{r_2} + \frac{kq_3}{r_3}$$



Where between the point charges is the electric potential ZERO?

$$V_p = 0$$

$$\frac{5}{10-x} = \frac{3}{x} \quad \Delta V = 0.$$

$$V_1 + V_2 = 0$$

$$x = 3.75 \text{ cm}$$

$$\frac{kq_1}{10-x} + \frac{kq_2}{x} = 0 \quad \rightarrow \quad \frac{x(5)}{10-x} = \frac{-x(-3)}{x}$$

Work done by the electric field W_{field}
Vs.

Work done by an external force W_{external}

To move a point charge

$$W_{\text{ext}} = \Delta U$$

$$W_{\text{ext}} = q\Delta V$$

$$W_{\text{ext}} = -\Delta KE$$

$$W_{\text{field}} = -\Delta U$$

$$W_{\text{field}} = -q\Delta V$$

$$W_{\text{field}} = \Delta KE$$

$$W_{\text{ext}} = q\Delta V \rightarrow q(V_f - V_i)$$

$$W_{\text{field}} = -q\Delta V \rightarrow -q(V_f - V_i)$$

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

• Equipotential lines

1. perpendicular to the electric field.
2. lines do not intersect.
3. Electric field lines are directed from high voltage to low voltage.
4. zero work is needed to move a charge between any 2 points on the same equipotential line.
5. (ΔV) potential difference between any 2 points on it, is zero.

The potential difference between 2 points along the axis.

Formulas:

$$E_x = - \frac{dV}{dx} \text{ (derivative)} \quad \text{Both have negative sign}$$

$$\Delta V = V_B - V_A = - \int E \cdot ds \text{ (anti-derivative)}$$

Example:

$$V = 2x^2 + 4$$

Find the electric field at $x = 2\text{m}$

$$E = - \frac{dV}{dx} = -4x \\ = -4(2) = -8 \text{ V/m}$$

Example

$$E = 3x$$

Find ΔV between $x=1$ and $x=2$.

$$\Delta V = - \int_1^2 3x dx \\ \Delta V = -4.5 \text{ V}$$

If they ask for the magnitude use:

$$E = \sqrt{E_x^2 + E_y^2}$$

$$W = \Delta KE = -\Delta U = -q\Delta V$$

Example:

A proton travels from $V = 5\text{V}$ to $V = 3\text{V}$, from rest

a. Find its Kinetic energy

$$\Delta KE = -q(V_f - V_i)$$

$$\Delta KE = -q\Delta V$$

$$KE = -(1.6 \times 10^{-19})(3-5)$$

$$KE = 3.2 \times 10^{-19} \text{ J or } 2\text{eV}$$

b. find its speed (mass of proton = 1.67×10^{-27} kg)

$$KE = \frac{1}{2}mv^2 \longrightarrow v^2 = \frac{KE}{\frac{1}{2}m} \longrightarrow v = \sqrt{\frac{KE}{\frac{1}{2}m} \cdot \frac{2}{1}} = \sqrt{\frac{2KE}{m}}$$

$$v = \sqrt{\frac{2(3.2 \times 10^{-19})}{1.67 \times 10^{-27}}} = 1.9 \times 10^4 \text{ m/s}$$

End of topic 3. ☺