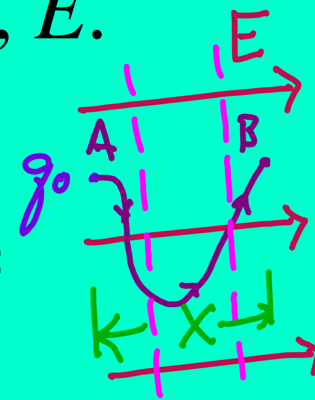
Potential Difference, Electric Potential, Point Charge

Do not worry about your difficulties in Mathematics. I can assure you mine are still greater.

Einstein

Potential Difference

- Imagine a test charge q_o in an electric field, E.



- Work done by field on test charge $= \int F \cdot ds = \int q_o E \cdot ds$
- $dU = -\text{Work} = -\int q_o E \cdot ds = -q_o E x$

$E = \frac{F_e}{q_o}$

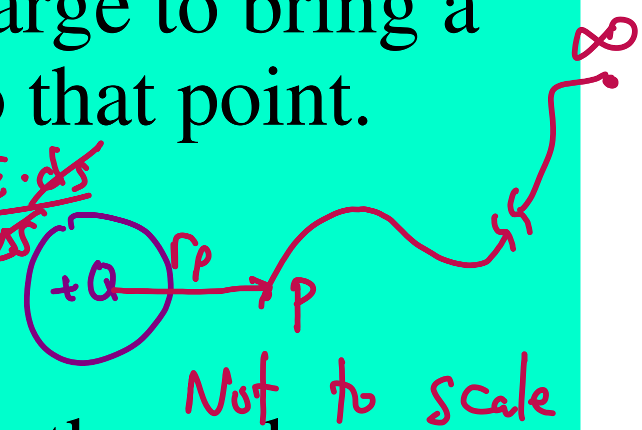
- $\Delta U = -q_o \int E \cdot ds$
- This path (line) integral does not depend on the path taken from A to B.
- This is the definition of a conservative force!

Electric Potential

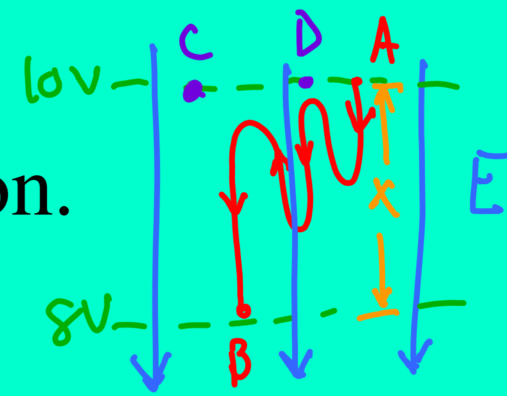
- The PE_g per unit charge (U/q_o) is independent of the test charge and has a unique value at every point in an E-field.
- This quantity (U/q_o) is called potential, electric potential, voltage
- $\mathbf{V = U/q_o}$ $\quad$ $\frac{J}{C}$ = Volt, V
- Is electric potential a scalar or vector?
- $\mathbf{\Delta V = \Delta U/q_o = -\int E \cdot ds}$

Electric Potential continued

- As with PE, only *differences* in electric potential are meaningful.
- Therefore we can let any convenient point have a potential of zero.
- Electric potential at an arbitrary point in an E-field equals the work required per unit charge to bring a positive test charge from ∞ to that point.
- $V_P = -\int_{\infty}^{r_P} \mathbf{E}\cdot d\mathbf{s}$ $V_P - V_\infty = \Delta V$ $-\frac{\Delta V}{\Delta s} = \frac{E\cdot ds}{ds}$
- $1\ V \equiv 1\ J/C$ & $1\ N/C = 1\ V/m$
- The energy an electron gains moving through a potential difference of 1 V is the electron volt
- $1\ eV = 1.6 \times 10^{-19}\ C\cdot V = 1.6 \times 10^{-19}\ J$



Potential Difference in Uniform E-fields



- Consider E-field in negative y direction.
- $V_B - V_A = \Delta V = -\int E \cdot ds = -Ex$
- $\Delta V = -E \cdot x$
- Minus sign indicates $V_B < V_A$
- Electric field lines always point in the direction of ___decreasing___ electric potential.
- $\Delta U = -q_o Ed = -q_o Ex$ for uniform field
- A positive charge ___loses___ electric potential energy when it moves in the direction of the E-field.

P.D. in Uniform E-Field

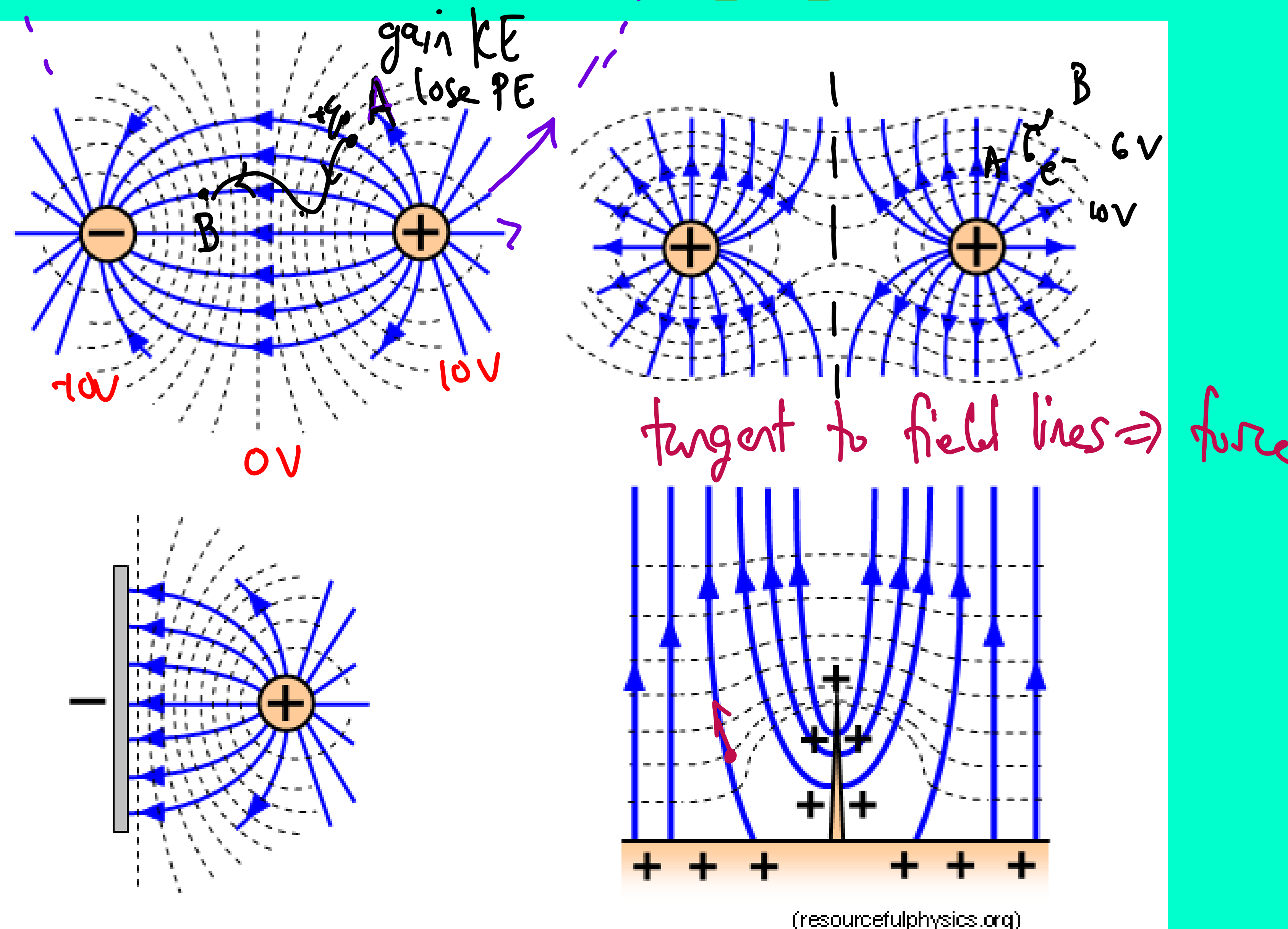
- As the charged particle gains KE, it loses an equal amount of PE.
- Negative charges gain electric potential energy when it moves in the direction of the electric field. All points in a plane perpendicular to a uniform E-field are at the same electric potential.

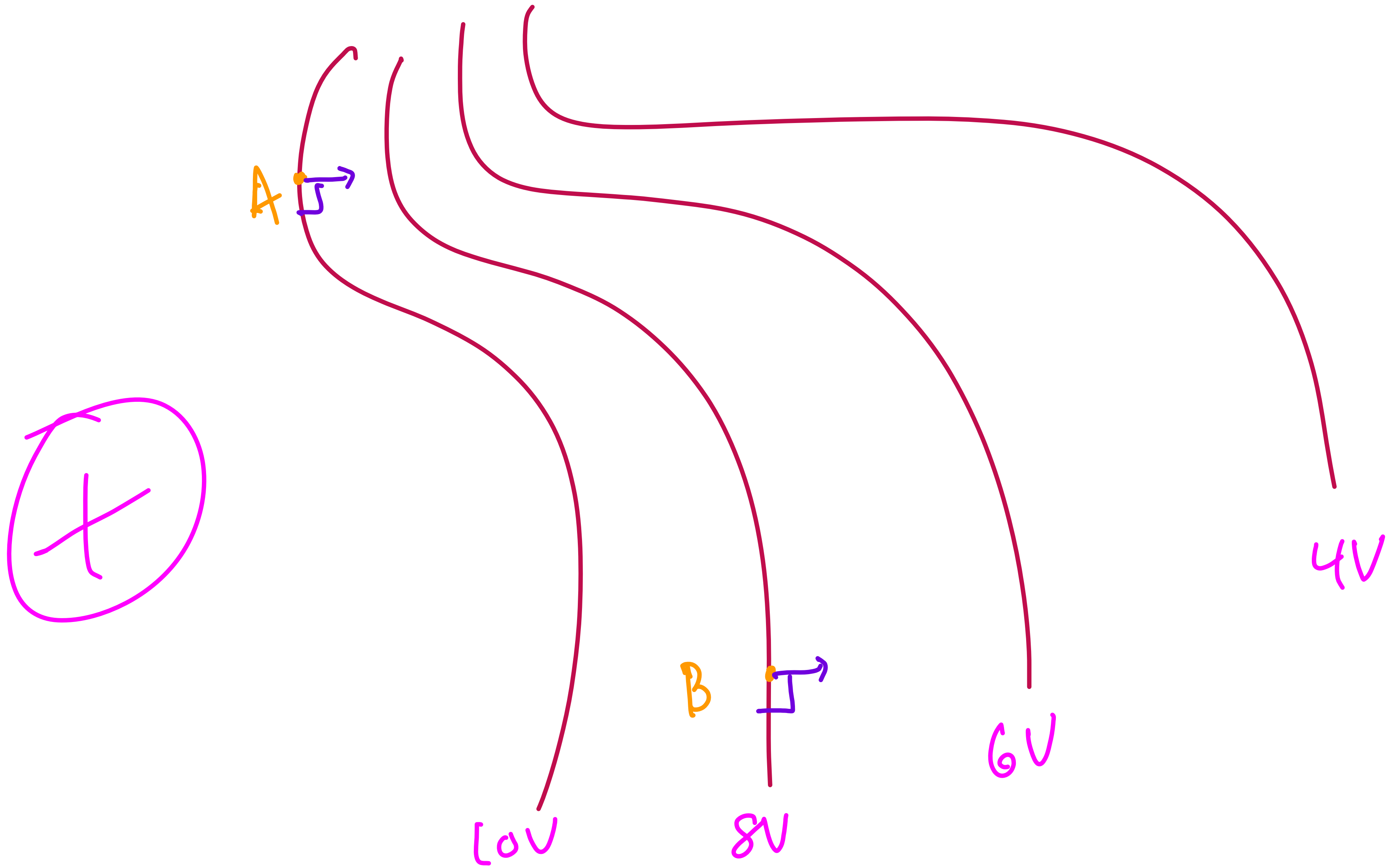
- The name *equipotential surface* is given to any surface consisting of a continuously distribution of points having the same electric potential. same potential
- No work is done to move a test charge between any two points on an equipotential surface.

Summary

- $V = \frac{U}{q_0}$, $\Delta U = -q_0 \int E \cdot ds$
- $\Delta V = \frac{\Delta U}{q_0} = -\int E \cdot ds$
- To find the potential at any point in an electric field start at ___∞___ and move ___inward___

Field Lines and Equipotentials





A
B
10V
8V
6V
4V