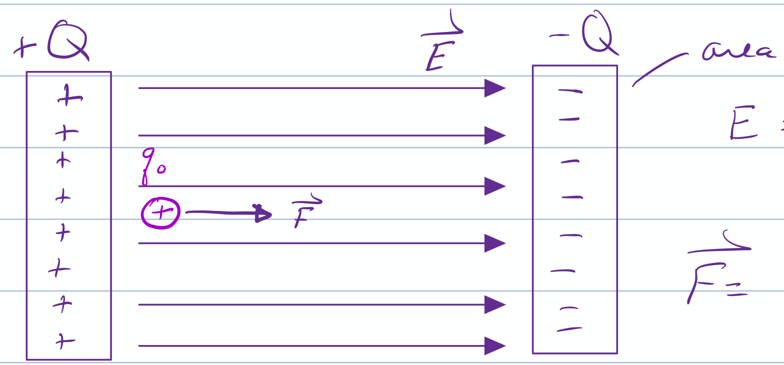
21.1 Electric Potential Energy and Electric Potential

The electric force can do work.

e.g. parallel plates. Drop a particle q_0 at the left hand side. It accelerates. We can use $F = ma$ to find the final speed, but think about work/energy instead.



$E = \frac{\sigma}{\epsilon_0}$

$\vec{F} = q_0 \vec{E}$

Think about work and kinetic energy

$K_i + W = K_f$

$K_i + F \cdot d = K_f$

$K_i + (q_0 E) \cdot d = K_f$

Recall how we thought about potential energy.

$K_i + U_i = K_f + U_f$

$K_i - (U_f - U_i) = K_f$

$K_i - (\Delta U) = K_f$

compare to $K_i + W = K_f$

$\therefore -\Delta U = W$

$\Delta U = -W$

(i.e. when the system does work, it loses potential energy.)

For the electric force here, it suggests there is a potential energy $\Delta U = -W = -(q_0 E)d$

Units: Joules

Note this factors into 2 parts

(1) arrangement of other charges (E, d)

(2) The particular charge q_0 you put down.

Inspired by that factoring, define

ΔU = Electric Potential Energy (Joules)

ΔV = Electric Potential

$$\Delta V \equiv \frac{\Delta U}{q_0} \quad \text{or} \quad \Delta U = q_0 \Delta V$$

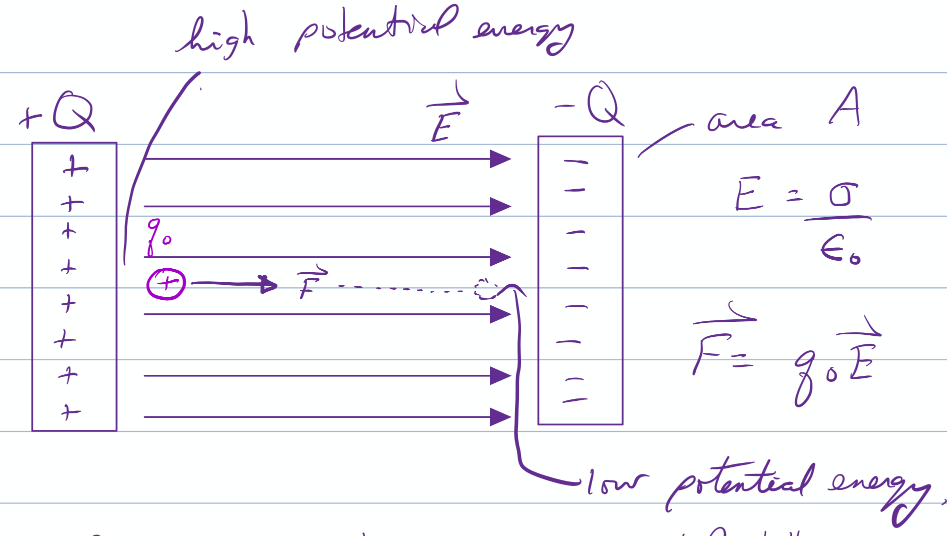
Units of $\Delta V = \frac{\text{Joules}}{\text{Coulomb}} \equiv$ Volts.

Another energy unit: suppose you move a proton (charge $1e$) through a potential difference of 1 Volt. $\Delta U = e\,\Delta V = e \cdot (1V)$

= 1 electron-Volt

$$\boxed{1\ eV = 1.602 \times 10^{-19}\text{J}}$$

Returning to the parallel plates:



$E = \frac{\sigma}{\epsilon_0}$

$\vec{F} = q_0 \vec{E}$

Release from rest. $K_i = 0$. $U_i =$ "high."
$\vec{F}$ does work. Final state has $K_i =$ "high", $U_f =$ "low."

As we observed in mechanics, the force tends to make particles go from high potential energy to low potential energy.

How do you calculate V? Section 21.4
What do you do with V? Section 21.3

Some general observations about $\Delta U = q_0 \Delta V$

1) only differences matter.
2) $\Delta U = (q_0)(\Delta V)$

q_0: The specific charge you place
ΔV: potential set up by other charges

analogy: gravity: $\Delta U = m_0 (g \Delta y)$

m_0: the specific mass you place.
$g \Delta y$: set up by Earth

Read section 21.1 for a good overview.

21.2 Sources of Electric Potential

Read:

ΔV = potential difference = Voltage difference

Energy application: $\Delta U = q_0 \Delta V$

static shock: q_0 small, ΔV large

outlet: q_0 Large, ΔV moderate

Safety issues typically involve energy – ΔU.