Chapter 19 - Electric Potential

Electrical Potential Energy	Electrical Potential	Electrical Potential Difference
Total Energy, like gravitational potential energy	Energy due to position, stored, energy per charge, due to charged particle(s) creating field	Difference in potential between 2 points, like grav. pot energy, makes charged particles move, "voltage"
Ue	V	ΔV
units = J	Units = J/C = volts = v	Units = J/C = volts = v
ΔUe = (ΔV)q	V = Ue/q	ΔV = Vb-Va

NOTE: ALL ARE SCALARS!!!

Equations for Ue and V for a POINT CHARGE

V = energy/charge = Work/charge

$W = Fx = (kqq/r^2)r = kqq/r = U_e$

$W/q = kqq/rq = kq/r = V$

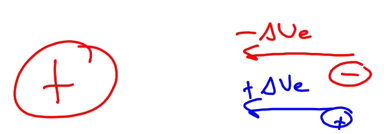
signs matter!!! need to think...is it gaining or losing energy? is field doing work on the particle or is the particle doing work on the field?

$-W = \Delta U_e$

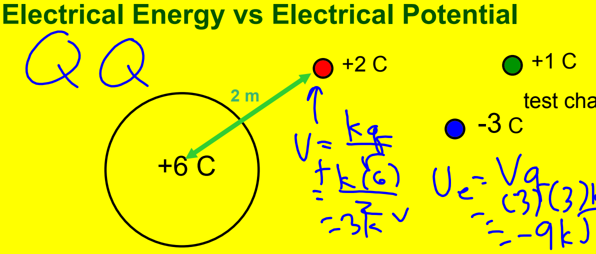
$-W = q\Delta V$

+ V = +q

-V = -q



Electrical Energy vs Electrical Potential



- V is determined by a +1C test charge; it is INDEPENDENT of a second charge; it DEPENDS only on charge creating field

  V = kq/r

- U_e is determined when another charged particle is placed at a point, it is DEPENDENT on a second charge

  $U_e = (kq/r)q = kqq/r$

+2C —2m— • —3m— −3C

V = ?

U_e (+2C)

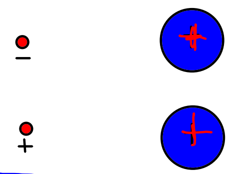
$V = \frac{kq}{r} + \frac{kq}{r}$

$= \frac{2k}{2} - \frac{3k}{3} = 0$

$U_e = (0)(2) = 0$

Work

Increasing the U_e of a charge requires +W ON the particle



goes closer = +ΔV

-q takes -W

+ q takes + W

moves away = -ΔV

- q takes ~~-~~+W

+ takes -W

$-W = (\Delta V)q = -\Delta U_e$ particle

-W = decelerates

+W = accelerates

$W = \Delta KE = 1/2m(v_f^2 - v_o^2)$

use mass of electron = **9.11×10^{-31} kg**

Most common to use:

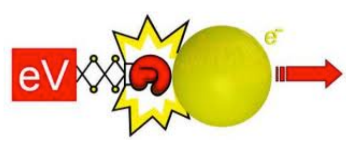
$\Delta Vq = 1/2m(v_f^2 - v_o^2)$ $= \Delta E = W$

note: V= really ΔV because electron will NOT move if there is no difference in potential

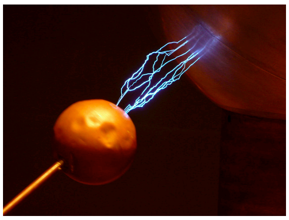
Electron Volt = unit of energy NOT potential

1 eV = energy of ONE electron moving through 1 J/C potential difference

$1\text{ eV} = (1\text{ J/C})q_e = 1.6 \times 10^{-19}\text{ J}$



Demo - van de Graaf and lightning and light



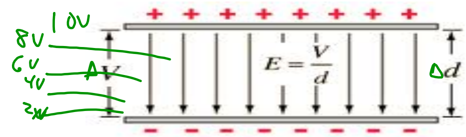
Electric potential and energy between parallel plates

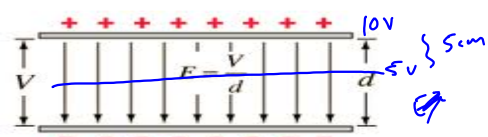
E field is uniform

ΔV is difference in distance between two points relative to plates along E field line

Highest V = closest to + plate

V changes uniformly with distance





W = Fx = Eqx..where x = dist between equipotential lines

But W = ΔVq and x = Δd so...

ΔV = EΔd

but usually write

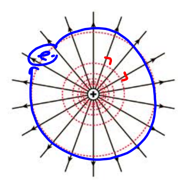
V = Ed

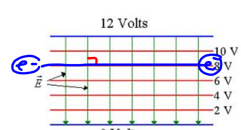
$E = \frac{\Delta V}{\Delta r}$

$\Delta V = Er$

Equipotential Lines

"lines" in an E-field with equal potential





For point charge

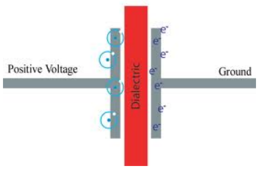
They are concentric circles

For parallel plate

They are parallel lines

Capacitor

- A device that holds charge
- Consists of conductor parallel plates sandwiching an insulator = dielectric



C= capacitance = amount of charge device can hold per potential difference

Capacitance	C	F

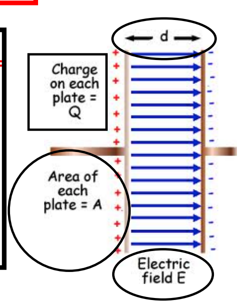
units = Farads = F

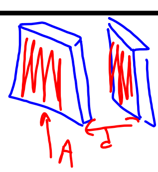
q = CV (where V is really ΔV)

C depends on size of Capacitor AND dielectric

ε↓ **$C = \kappa\varepsilon_o A/d$** K K

- ↑κ = kappa = dielectric constant = Eo/E
- Eo = E field without dielectric
- ↓E = E field with dielectric
- so E = Eo/κ....bigger κ = smaller E....so can hold more q





Energy of Capacitor depends on V and q

W = stored energy = $(V_{avg})q$ = 1/2Vq ΔV

q = CV...so W = 1/2VCV = $1/2CV^2$

Energy = $1/2C\Delta V^2$ = $1/2q\Delta V$ $= U_c$

Energy density = Energy/Volume ΔV = Ed

$\frac{\text{Energy}}{\text{Volume}} = \frac{1/2CV^2}{Ad} = \frac{1/2(\kappa\varepsilon_o A/d)(Ed)^2}{Ad}$ ΔV = Er

Energy density = $1/2\kappa\varepsilon_o E^2$