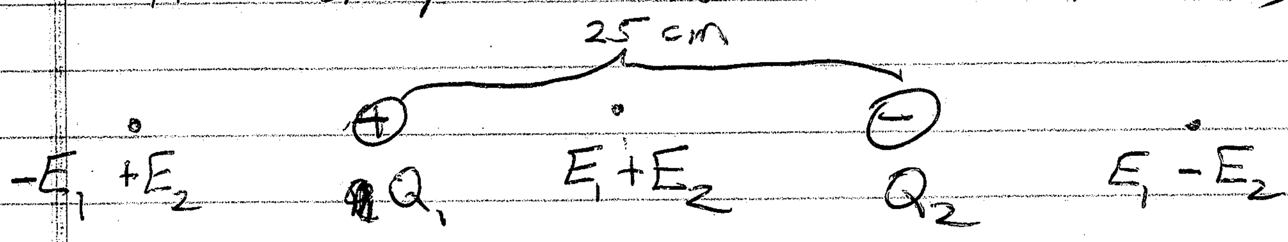
 Phys 1402 2017-07-06

HW1 Due Sunday Night
Quiz1 Monday

E-Field of point charge review (HW1-13)



Each generates $E = \frac{kQ}{r^2}$ • away from ⊕ • toward ⊖

Goal: $E_{Tot} = 0$ — E_1 & E_2 are magnitudes

- In between $E + E_2$ can't be zero

Suppose Q_1 is "stronger" than Q_2.

Ex: $Q_1 = +5\,nC$ $Q_2 = -3\,nC$

Need $E_1 = E_2$ ← magnitude!

$$\frac{kQ_1}{r_1^2} = \frac{kQ_2}{r_2^2}$$

$$\frac{5}{r_1^2} = \frac{3}{r_2^2}$$

r_2 is smaller, point is on right.
Set $r_1 = r_2 + 0.25$

$$\frac{5}{(r_2+0.25)^2} = \frac{3}{r_2^2} \longrightarrow \frac{2.236}{r_2+0.25} = \frac{1.732}{r_2}$$

Same Idea - 4 different names for V

- Electric Potential (not P.E.)
- Potential Difference
- Electromotive Force (EMF)
- Voltage

In electrostatics

- Potential is PE per Charge

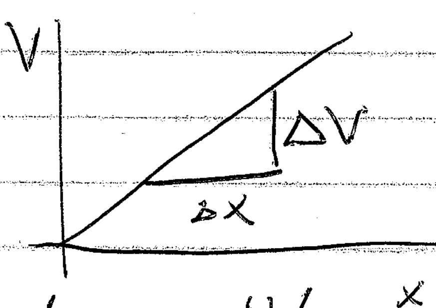
$$\Delta V = \frac{\Delta PE}{q} \qquad \Delta PE = q\,\Delta V$$

Typically, any small q experiences same ΔV.
ΔV describes the electrical environment.

- E-Field is slope of V.

$$E = -\frac{\Delta V}{\Delta X}$$

↳ E points "downhill"



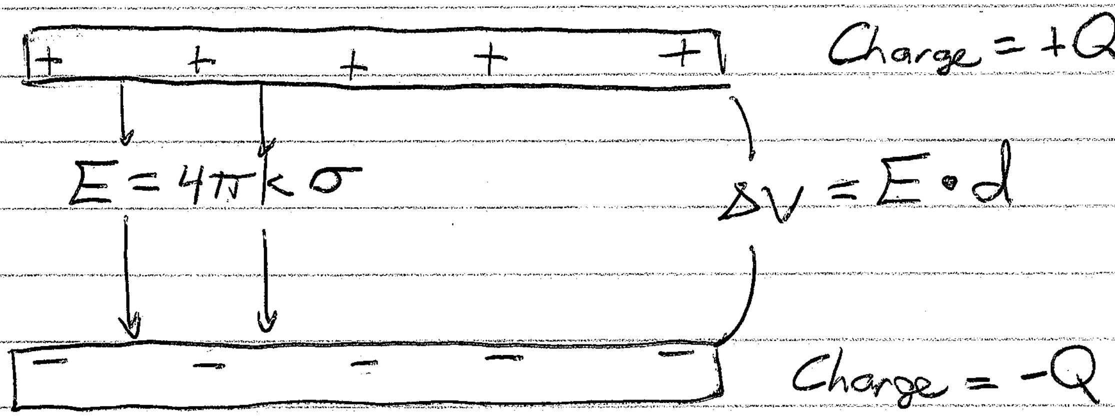
E can be measured in V/m or N/C.
They are equivalent.

Ex: 500 V between plates spaced 0.015 m apart.

$$|E| = \frac{\Delta V}{\Delta X} = \frac{500\,V}{0.015\,m} = 33300\ V/m$$

How do we set up a Uniform E-Field?

Parallel Plate Capacitor



Charge per Area $\sigma = Q/A$

Note: E is proportional to Q

ΔV is proportional to Q, also.

Capacitors: Storage of Charge and Energy.

- Two nearby storage places. (Metal Plates)
- Charge is always balanced (+Q, −Q)
- From Far away, total Q = 0
  (Van de Graaf has +Q w/o −Q)
- Charge prop to voltage

$$Q = C\,V$$

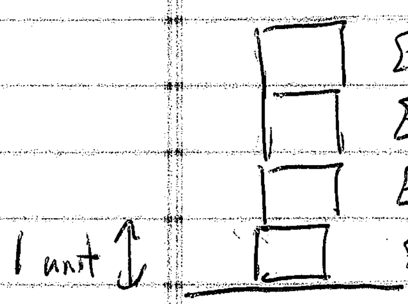
↑ charge in coulombs (C)

← Capacitance in farads (F)

← voltage, ΔV

Potential Energy of a Capacitor

Energy of a ~~pile~~ stack of bricks



Energy $= 3mg$
Energy $= 2mg$
Energy $= mg$
Energy $= 0$

Total Energy $= 6\,mg$
Total Mass $= 4m$
Top height $= 3$ units

What if we try $PE = Mgh = 4m\,g\,(3) = 12\,mg$ (M = Total mass, h = Top height)

This is twice as big as the real energy.

In reality, each brick was at a different height.

Back to capacitors:

If we <u>already</u> have ΔV: $\Delta PE = q\,\Delta V$

If we build ΔV from Q: $\text{Energy} = \frac{1}{2}QV$

Also: $Q = CV$, so $\text{Energy} = \frac{1}{2}CV^2$

How are batteries different?

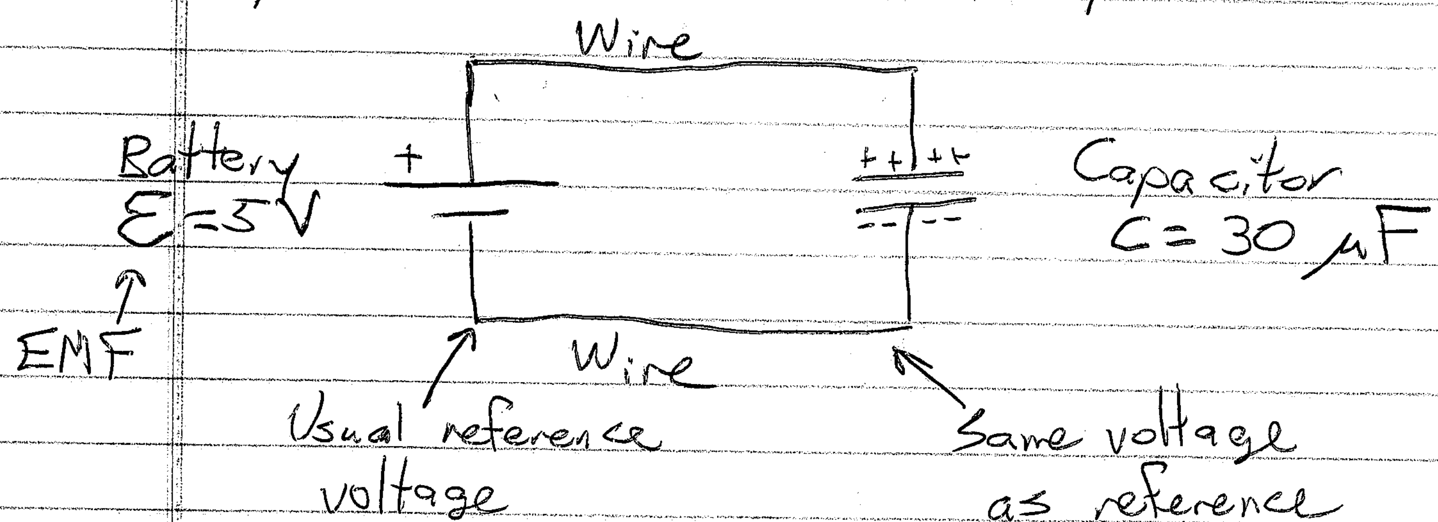
- Generate Q and V chemically.
- Each charge q has same V when generated.

$\text{Energy} = QV$

In electrostatics, metals are special.

- $E = 0$ on the inside
- $\Delta V = 0$ between any 2 points on the same piece of metal.
- $V =$ const on the metal piece.

Capacitor connected to a battery:



The whole top wire is "at 5.0 V" with respect to the reference.

There is 5V "across the capacitor"

$$Q = CV = (30 \mu F)(5.0 V) = 150 \mu C$$

Since both ends are connected, we say the batt & cap are <u>in parallel</u>.

Parallel $\longrightarrow$ Same Voltage