① Phys 1402 2015-09-08 Lec 4

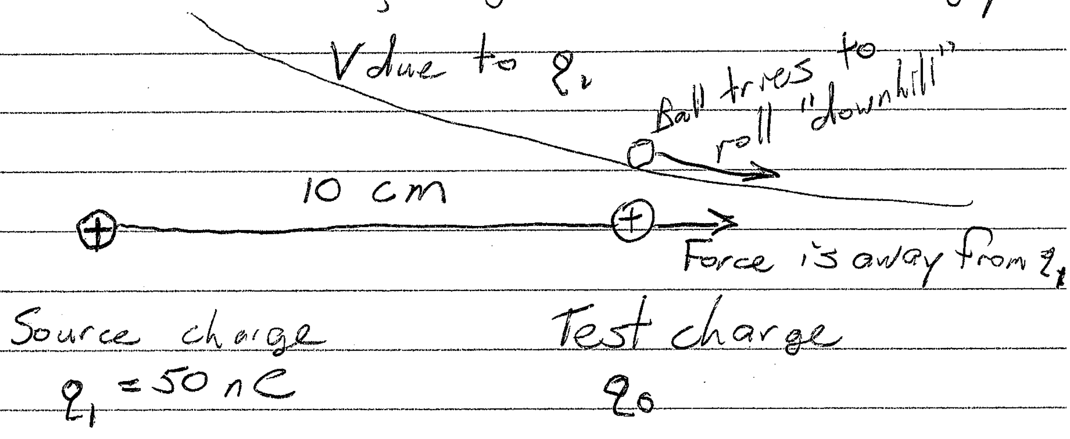
Roles of electric field (so far)

- Force per unit charge
- Flow of electric flux
- Slope of electric potential "landscape".

What is electric potential? (V)

- Energy per unit charge
- High energy = unfavorable
- Charge @ high energy is like
  a ball high on a hill.

For a ⊕ charge, high ⊕V is high energy.
For a ⊖ charge, high ⊕V is low energy.



q_0 wants to go toward right
that is "downhill"

$$\text{Slope in general} = \frac{\text{Rise}}{\text{Run}} = \frac{\Delta V}{\Delta x}$$

②

$V = \frac{kq_1}{r}$ Potential due to a point

Distance	Potential
0.1 m	$V = \frac{k(50 \times 10^{-9} C)}{(0.1 \text{ m})} = 4500 \text{ V}$
0.101 m	$V_2 = 4455 \text{ V}$
$\Delta X = 0.001$ m	$\Delta V = -44.6 \text{ V}$

$$\frac{\Delta V}{\Delta X} = \frac{-44.6}{0.001} = -44600 \text{ V/m}$$

What is E?

$$E = \frac{kq_1}{r^2} = \frac{k(50 \times 10^{-9} C)}{(0.1 \text{ m})^2} = 45000 \text{ N/C}$$

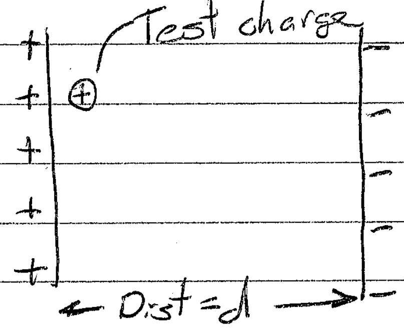
$$E = -\frac{\Delta V}{\Delta X}$$

Point Charges
- V is easy to calculate
- Add values as normal numbers
- E is not "uniform"

Recall Surface Charge

$$E = 2\pi k\sigma \quad \text{(pointing away from } \oplus \text{)}$$

Consider two opposite σ's:



$$\sigma_1 = 250 \frac{nC}{m^2} \qquad \sigma_2 = -250 \frac{nC}{m^2}$$

In Between:
$$\begin{aligned} E &= E_1 + E_2 \\ &= 2\pi k\sigma_1 + 2\pi k\sigma_2 \\ &= 4\pi k\sigma \\ &= 28270 \ N/C \end{aligned}$$

Outside $E = 0$

Test charge feels force of $F = q_0 E$

In gravity, drop from rest gains

KE of $\underbrace{mg}_{F}\underbrace{h}_{dist}$

Release test charge, its energy is

$k = 9\times10^{9}\ Nm^2/C^2$

$\varepsilon_0 = 8.85\times10^{-12}\ \frac{C^2}{Nm^2}$

$$KE = F\cdot d = q_0 E d = q_0\, 4\pi k\sigma d$$

$$\frac{KE}{q_0} = 4\pi k\sigma d = \frac{\sigma d}{\varepsilon_0} = \frac{Qd}{\varepsilon_0 A}$$

$$V = \frac{Qd}{\varepsilon_0 A}$$ Parall Plate Capacitor

Voltage   Charge

$$Q = V\left(\frac{\varepsilon_0 A}{d}\right)$$

$$Q = V\,(\text{geometry factor})$$

$$Q = \underset{\uparrow\ \text{capacitance}}{C}\,V$$

V acts like a "pressure".

It acts on q_0 <u>and</u> on Q.

Start with uncharged metal plates:

- $V = Q/C = 0$
- Move some charge from one to the other
- $Q_1 = +\text{small}$ $Q_2 = -Q_1$
- $Q = Q_1$ is "the charge of the capacitor"
  Note $Q_1 + Q_2 = 0$, always
- It's still easy to move charge
  because V is small.
- Keep going, Q gets large
- $V = Q/C$ hits its limit.
    - External V limited = ok
    - Max V of cap exceded = bad

Energy $= V_{avg}\, Q = \frac{1}{2} V_{max}\, Q$