 Phys 2426 2017-07-06 Lec 3

HW1 Due Sun Night (SMTE-0095 also)
Quiz 1 Monday

For two vectors to total zero;
They must be equal and opposite

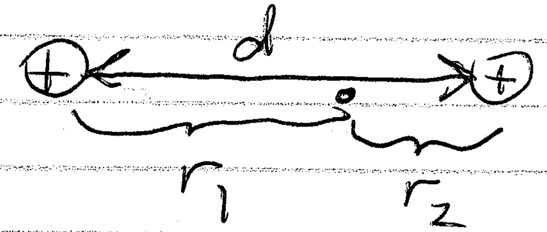
$E_1 = E_2$ Magnitudes!

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

$$\frac{Q_1}{Q_2} = \frac{r_1^2}{r_2^2} \qquad \frac{\sqrt{Q_1}}{\sqrt{Q_2}} = \frac{r_1}{r_2}$$

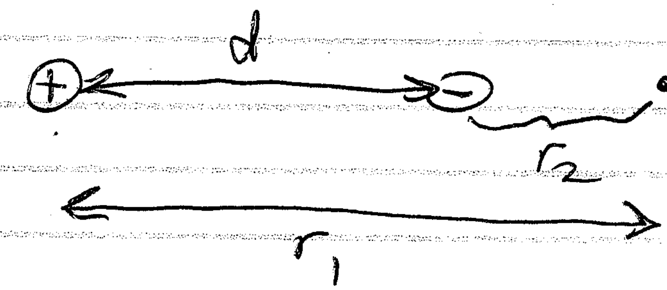
If the point is in between:

$$r_1 + r_2 = d$$



If the point is outside;

$$d + r_2 = r_1$$



Names for quantity measured in volts (V):

- Electric Potential (not potential energy)
- Potential Difference
- Electromotive Force (EMF)
- Voltage

Two main uses in electrostatics:

- Gives energy to charges

$$\Delta U = q \Delta V$$

Energy = Charge • (~~Char~~ Energy per Charge)

- Electric Field is negative gradient of V.

$$E_x = -\frac{dV}{dx}$$

↑ Component of $\vec{E}$

Vector $\vec{E}$ points "downhill"

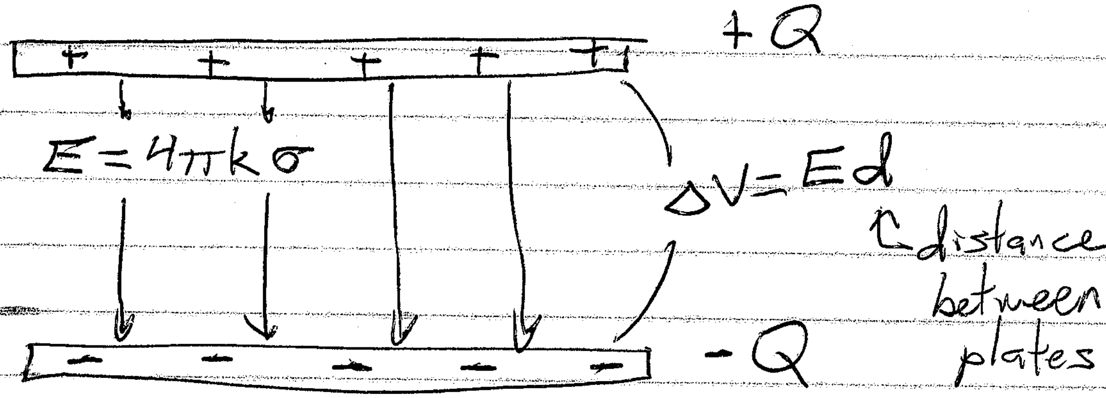
Average value $|E_{avg}| = \frac{\Delta V}{\Delta x}$

Recall $U_g = mgy$ $F_g = -mg = -\frac{dU_g}{dy}$

③

Parallel Plate Capacitor

- Stores Charges by keeping ⊕ and ⊖ nearby but separate
- Need 2 hunks of metal



Charge density: $\sigma = Q/A$

Note: E is propto Q

If $E = -\frac{\Delta V}{\Delta x} \rightarrow \Delta V = -\int E\,dx = -E\Delta x$

ΔV is propto Q $\Rightarrow Q = CV$

Charge on one plate or other (→ Q); Capacitance (→ C); ΔV (→ V)

$$Q = \sigma A = \frac{E}{4\pi k} A = \frac{V/d}{4\pi k} A = \boxed{\frac{A}{4\pi k d}} V$$

$$= \frac{\varepsilon_0 A}{d} V$$

Batteries vs. Capacitors

- Both store energy
- Both supply charges @ voltage.

Battery – chemical reaction generates voltage. Every q has same voltage.

$$\text{Total energy} = \int V\,dq = \boxed{VQ}$$

Ex: 3300 mAh battery

$$Q = 1.2 \times 10^{4}\ C$$
$$V = 4.5\ V$$

$$\text{Energy} = (1.2\times10^{4}\ C)(4.5\ V) = 54000\ J$$
$$= 54\ kJ$$

Cost $\quad \$0.12 = 1\ kWh = 3.6\ MJ \rightarrow 0.2$ ¢

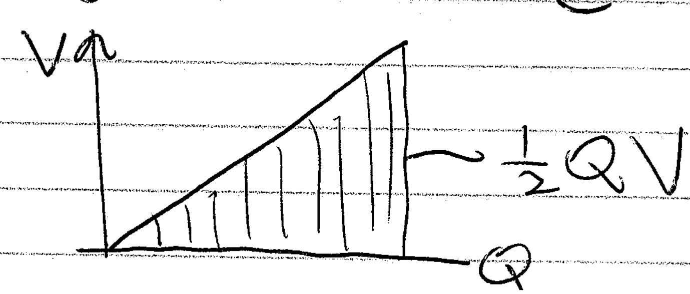
$$\$1 = 30\ MJ$$

Capacitors – store energy in E-field

$$\text{Energy} = \int V\,dq = \int \frac{q}{C}\,dq = \frac{1}{C}\frac{q^2}{2}$$

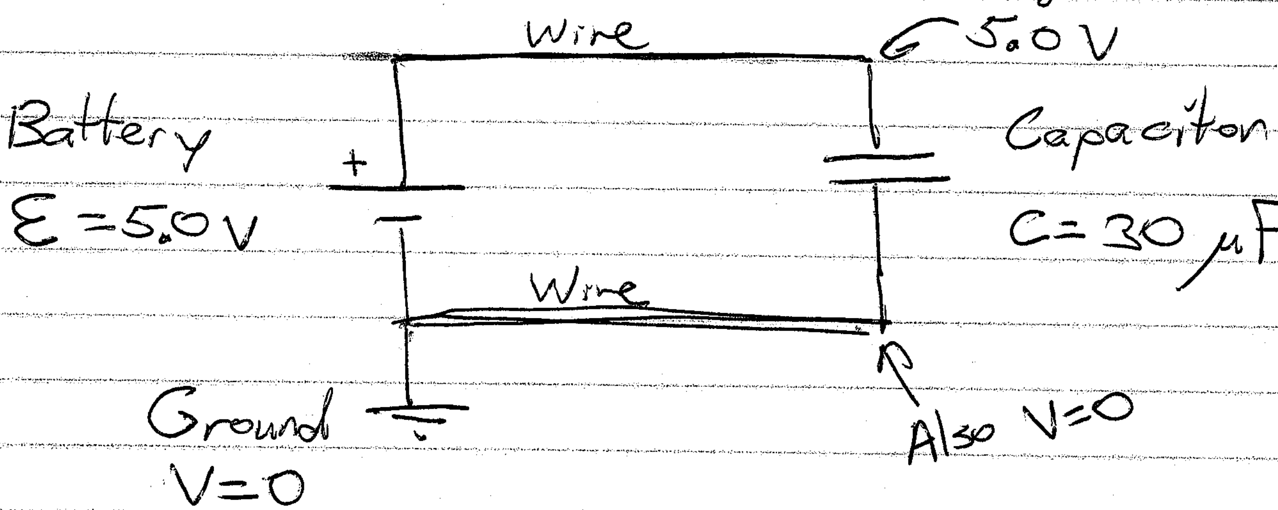
$q = CV$

$$= \frac{1}{2}\frac{Q^2}{C} = \boxed{\frac{1}{2}QV}$$
$$= \frac{1}{2}CV^2$$



(5) Capacitor in DC Circuit

- Charges (and hence current) cannot flow through a capacitor
- Metals are special in electrostatics,
  - $E = 0$ inside metal
  - $\Delta V = -\int E_x \, dx = 0$
  - $V = \text{const}$
  - Wires are each "at a voltage".

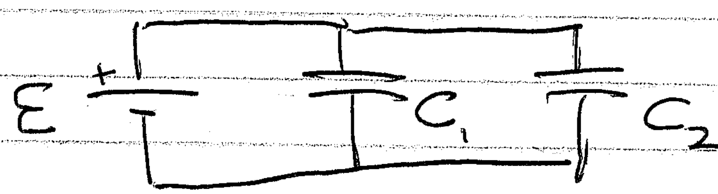


$V_c = 5.0\ V$

(Cap is in parallel with battery.)

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

In Parallel:



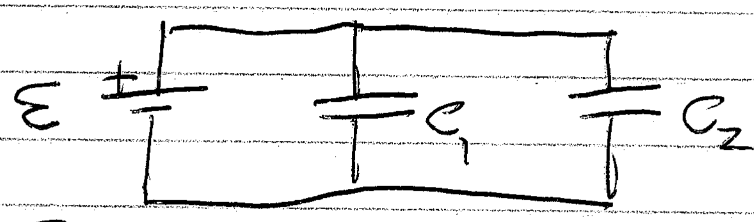
$\mathcal{E} = V_1 = V_2$ $\qquad Q_{Tot} = Q_1 + Q_2$

Acts like $\qquad Q_{Tot} = C_{eff}\,\mathcal{E}$

(6)

Capacitor Puzzle

Initially:



$q_{1i} = C_1 \mathcal{E}$

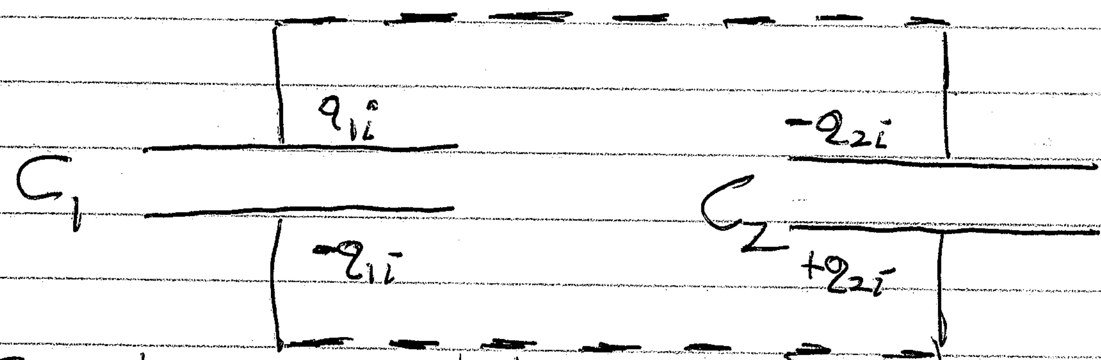
$q_{2i} = C_2 \mathcal{E}$

Then: Remove Battery.

Disconnect capacitors. q_1 is "stuck"

q_2 is "stuck"

Flip C_2 upside down.



Connect in parallel.

$q_{1f} = ?$

$q_{2f} = ?$

parallel $\Rightarrow$ $V_1 = V_2 = V$

Total charge can't change.

$$C_1 \mathcal{E} - C_2 \mathcal{E} = C_1 V + C_2 V$$

Before reconnect = After reconnect