Ass: { Ch. 19: 55, 75
ch. 20: 60, 79, 81.

1st. Ed:
ch. 19: #49, 71. 8-1.
ch. 20: #58, + web

Physics 102

Due: Oct. 1, Friday

Lecture 8.

Sept. 24, 2004. Friday.

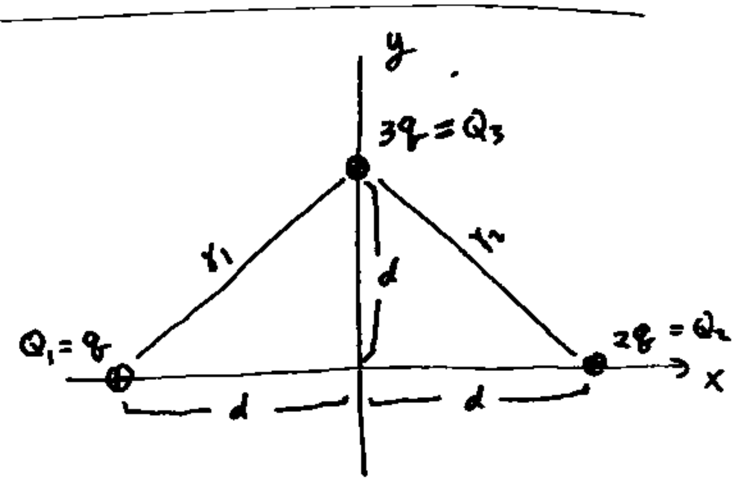
- Superposition Principle of the Electric Potential.

The total electric potential due to two or more charges is equal to the algebraic sum of the potentials due to each charge separately.

↑ because V is a scalar! cool!

- e.g. 20-4. p.656

a). Find the electric potential due to (Q_1, Q_2) at the location of Q_3.



b). Electric potential energy of charge Q_3.

c). what is the Kinetic energy of Q_3 when it has moved to ∞?

a). Eletric potential at Q_3: due to Q_1 and Q_2.

$$V_3 = \frac{KQ_1}{r_1} + \frac{KQ_2}{r_2}$$

$r_1 = \sqrt{d^2+d^2} = \sqrt{2}\,d$

r_2 = same.

$$= \frac{K}{\sqrt{2}\cdot d}(Q_1+Q_2)$$

(assuming $V(\infty)=0$)

$$= \frac{3Kq}{\sqrt{2}\,d}$$

b). Electric Potential Energy of charge Q_3:

$$U_3 = Q_3 \cdot V_3 = \frac{9Kq^2}{\sqrt{2}\cdot d}$$

c). at ∞, $U=0$.

~~Potential energy~~

Energy conservation: $K_i + U_i = K_f + U_f$.

$$0 + \frac{9Kq}{\sqrt{2}\cdot d} = K_f + 0$$

$$\therefore \quad K_f = \frac{9Kq}{\sqrt{2}\,d}.$$

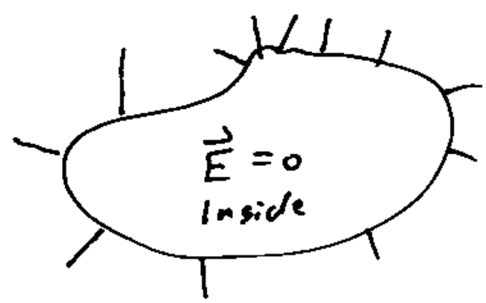
- Ideal conductors:

  charges can move freely.

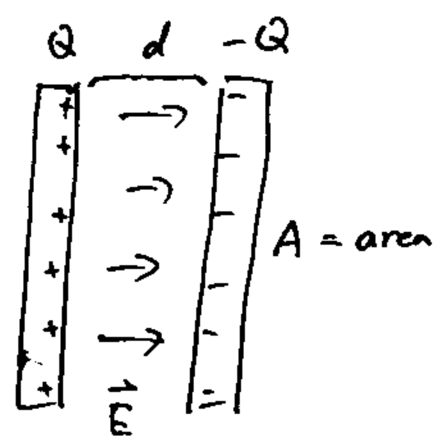
  ① an ideal conductor is an equipotential body.

  ②. $\vec{E}=0$ inside the conductor.

  ③ $\vec{E}$ is perpendicular to the surface.



- Parallel-plate capacitor.



$$E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A}.$$

Voltage:

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

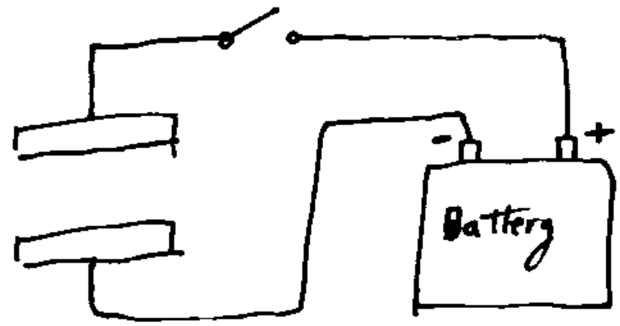
$$Q = \frac{\varepsilon_0 A}{d} V$$

$$Q = CV$$

C — capacitance (capability of holding charges)
(per unit voltage)

$C = \frac{Q}{V}$. for a parallel-plate capacitor: $C = \frac{\varepsilon_0 A}{d}$

- To charge a capacitor :



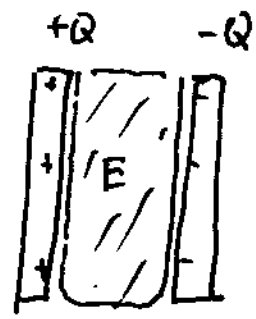
- How to increase the capacitance

① change the shape. (make A larger, d smaller. OR. change the shape)

② Insert a dielectric slab. (insulator) (can have polarization charge)

Idea: $C = \frac{Q}{V}$.

Reduce V by reducing E.

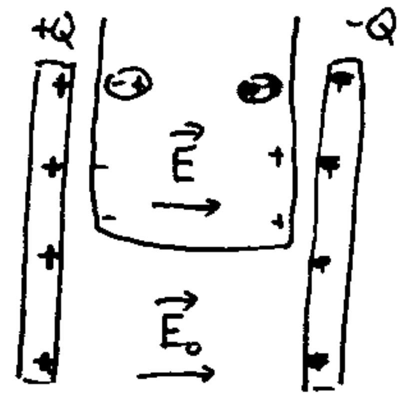


$V = V_+ - V_- = Ed$

How it works:

The $\vec{E}$-field inside the dielectrics is reduced by polarization charges.

The induced charges will partially shield the $\vec{E}$-field due to the free charges on the plates.



$E = E_0/K$.

K — dielectric constant of the material.

$E < E_0$

Then: $V = \frac{V_0}{k} = \frac{Qd}{A\varepsilon_0 k} = \frac{\sigma d}{A\varepsilon_0 k}$.

$$C = \frac{Q}{V} = \frac{K\varepsilon_0 A}{d}.$$

Note: dielectric constant of vacuum: $K_0 = 1$.

• Energy stored in a capacitor.

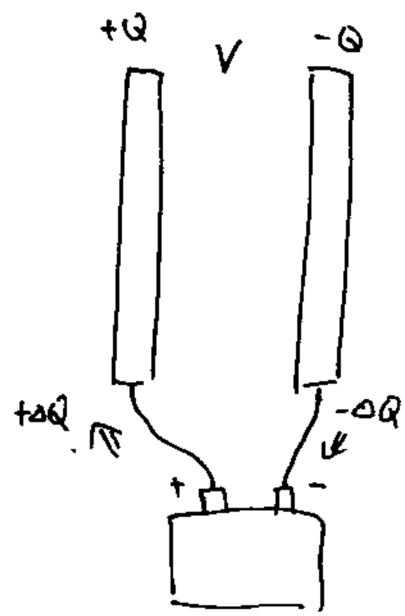
$$U = \frac{1}{2} QV.$$

why $\frac{1}{2}$?

Consider: the capacitor is being charged

in a time interval Δt.

ΔQ is transfer from the right ~~plate~~ plate to the left



change in potential energy.

$\Delta U = V \cdot \Delta Q$ but $V = \frac{Q}{C}$.

$= \frac{1}{C} \cdot Q \Delta Q$.

$dU = \frac{1}{C} Q dQ$

$\int_0^U dU = \frac{1}{C} \int_0^Q Q\, dQ$. $\therefore$ $\boxed{U = \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2} QV.}$ Energy stored