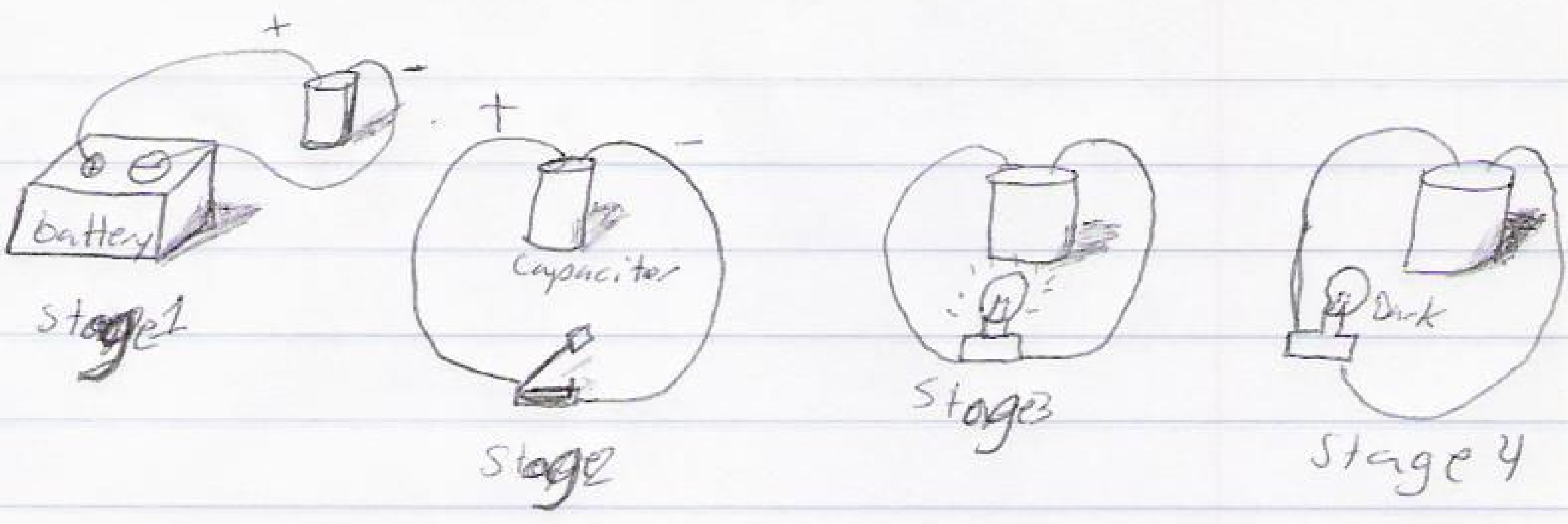
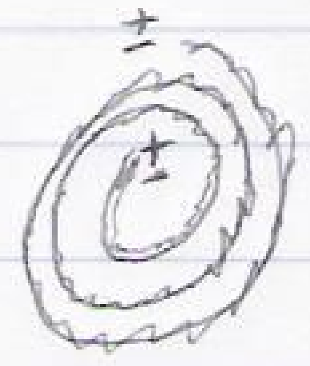
09/08/10

Notes

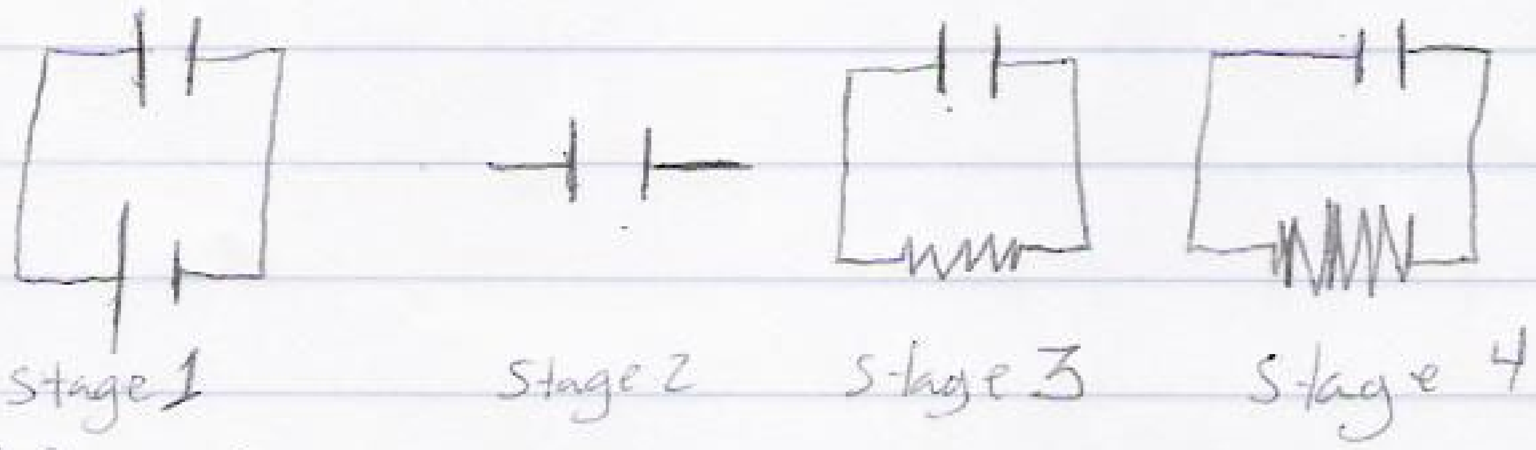


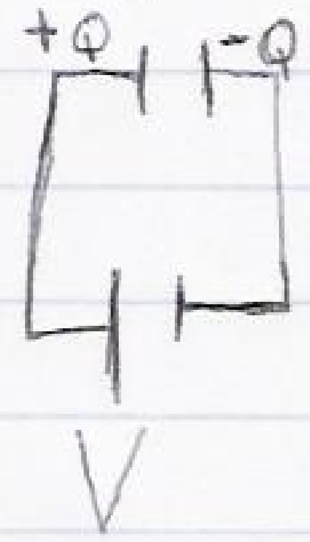
Stag



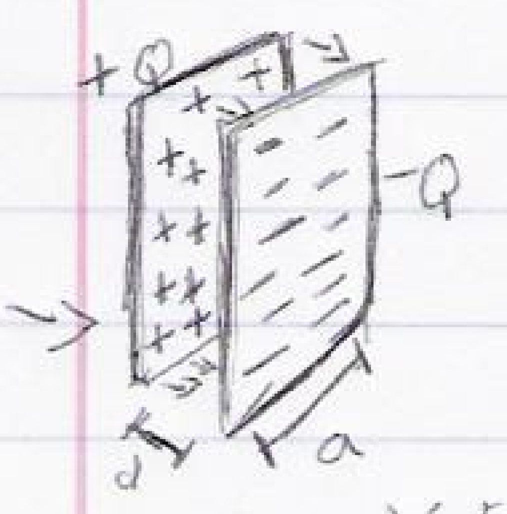
Capacitors store energy

Capacitors stores two opposite charges





Capacitance: $C = \frac{Q}{V}$



Two metal plates with Nothing in between

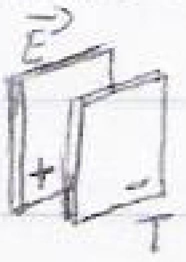
$d << a, b$ (Plates close together)

$\vec{E}$ Points from + to − in between plates

$V = Ed \Leftarrow \vec{E} = \frac{\sigma}{\epsilon_0}$ where $\sigma = \frac{\text{charge}}{\text{area}} = \frac{Q}{A}$ where $A = ab$

Capacitance: $C = \frac{Q}{V}$

For capacitance



$V = V_{TS} = V_S - V_T = -\int_T^S \vec{E} \cdot d\vec{l} = -\int_T^S E\,dl$

$V = Ed \Rightarrow$

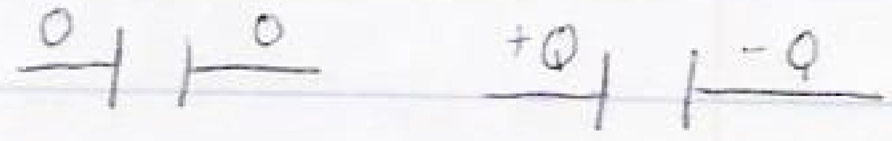
$$\frac{\sigma d}{\epsilon_0} = \frac{Qd}{A\epsilon_0} \Rightarrow C = \frac{Q}{V} = \frac{Q}{\frac{Qd}{A\epsilon_0}} = \frac{A\epsilon_0}{d}$$

$$1 \text{ farad} = \frac{1 \text{ coulomb}}{1 \text{ volt}}$$

Actual capacitors are typically in the range of $1\,\mu F$ to $1\,pF$ ($10^{-6}F$ to $10^{-12}F$)

$V = \frac{U}{q}$ Voltage $= \frac{\text{potential energy}}{\text{charge}} = \frac{\text{work done on charge}}{\text{charge}}$

|| electric potential



Charging a capacitor from $q=0$ to $q=Q$ stores ____ energy in the capacitor.

$C = \frac{Q}{V}$ $CV = Q$ $V = \frac{Q}{C}$

$\Delta U = q\Delta V$ when $q \approx$ constant

$\Delta U = V\Delta q$ when $V \approx$ constant

C = capacitance
V = voltage
$q = Q$ = charge

$$U = \int_{q=0}^{q=Q} dU = \int_0^Q V\,dq = \int_0^Q \frac{q}{C}\,dq = \frac{1}{C}\cdot\frac{Q^2}{2} = \boxed{\frac{Q^2}{2C}} = \frac{Q^2}{2Q/V} = \boxed{\frac{QV}{2}} =$$

$$\rightarrow = \frac{(CV)V}{2} = \boxed{\frac{1}{2}CV^2}$$

$$U = \int_{q=0}^{q=Q} dU = \int_{V=0}^{V=Q/C} q\,dV = \int_0^{Q/C} CV\,dV = C\cdot\frac{(Q/C)^2}{2} = \boxed{\frac{Q^2}{2C}}$$

Example 638

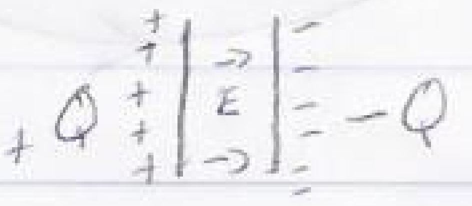
$C = kC_0$
$k > 1$

k = dielectric constant of the material

ϵ_0 = permittivity of free space $\qquad$ C_0 = Capacitance

$\epsilon = K\epsilon_0$ = permittivity of the material

Example



Vacuum $E = \frac{\sigma}{\epsilon_0}$

$K > 1$

K = dielectric constant of the material

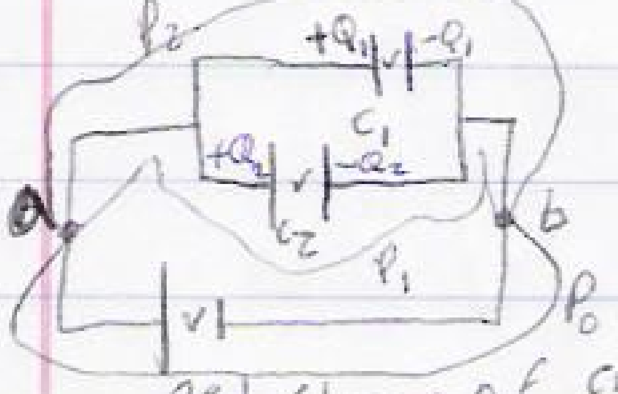
$\sigma = \frac{\text{charge}}{\text{area}} = \frac{Q}{A}$

$E = \frac{\sigma}{\epsilon} = \frac{\sigma}{K\epsilon_0} < \frac{\sigma}{\epsilon_0}$ $\quad$ E gets smaller for a fixed Q

$\Rightarrow V = Ed$ gets smaller $\Rightarrow C = \frac{Q}{V}$ get bigger

$$E = \frac{E_0}{K} \Rightarrow V = \frac{V_0}{K} \Rightarrow C = \frac{Q}{V} = \frac{QK}{V_0} = KC_0$$

Capacitors in parallel

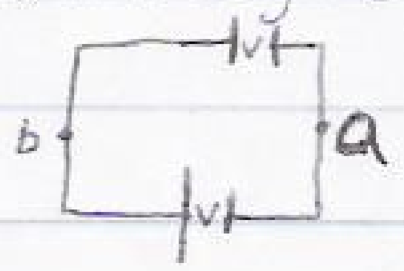


net charge of circuit = 0

$$V = V_{ba} = V_a - V_b = -\int_b^a \vec{E}\cdot d\vec{l} = -\int_{P_0} \vec{E}\cdot d\vec{l} = -\int_{P_1} \vec{E}\cdot d\vec{l} = -\int_{P_2} E_2 \Rightarrow$$

$$\Rightarrow d\vec{l} = -\int_{P_2} \vec{E}\cdot d\vec{l}$$

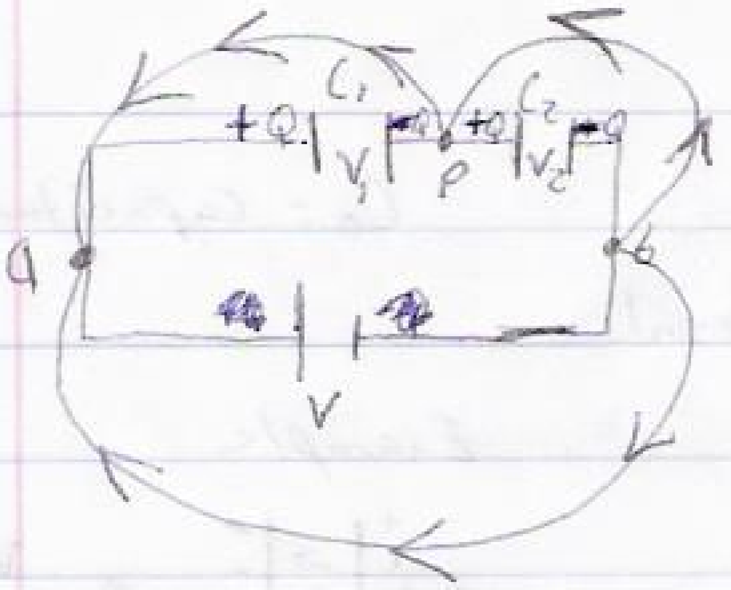
Equivalent Single Capacitor



Same amount of charge to leave each battery terminal: $Q = Q_1 + Q_2$

$$C_{eq} = \frac{Q}{V} = \frac{Q_1}{V} + \frac{Q_2}{V} = C_1 + C_2$$

$$\boxed{C_{eq} = C_1 + C_2}$$



$V_1 = V_a - V_p = -\int_p^a \vec{E} \cdot d\vec{l}$

$V_2 = V_p - V_b = -\int_b^p \vec{E} \cdot d\vec{l}$

$V = V_a - V_b = -\int_b^a \vec{E} \cdot d\vec{l}$

$V = V_1 + V_2$

$Q = Q = Q$

$$C_{eq} = \frac{Q}{V} \Rightarrow \frac{1}{C_{eq}} = \frac{V}{Q} = \frac{V_1}{Q} + \frac{V_2}{Q} = \frac{1}{C_1} + \frac{1}{C_2}$$

$\boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} \text{ ; capacitors in series}}$