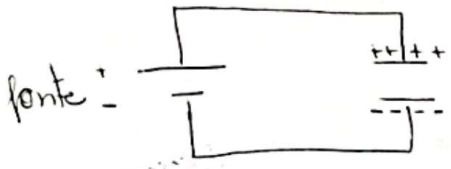
Cap 25 : Capacitância

- Capacitor
- Capacitância

Capacitor: dispositivo p/ armazenar energia e liberá-la de forma rápida
Ex: flash.

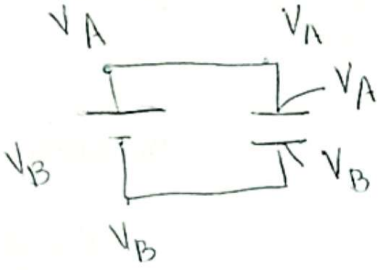
Capacitância ⇒ $C = \frac{q}{V}$ $\frac{C}{V}$: coulomb/volt = 1F farad

Carregando um capacitor:



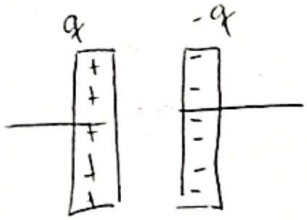
capacitor

Carga + migra p/ o menor potencial.



$V_A - \Delta V_C + \Delta V_F = V_A$

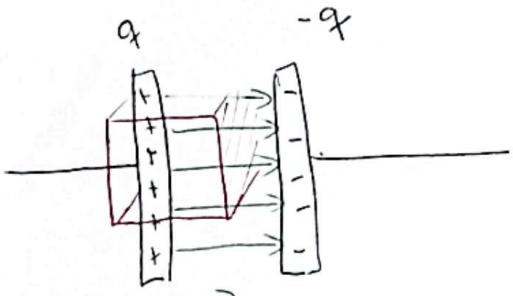
$\Delta V_C = \Delta V_F$

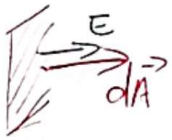


- Calculo de $\vec{E}$ dentro do capacitor
- " de ΔV (entre as placas)

Digitalizado com CamScanner

. Capacitor de cargas paralelas





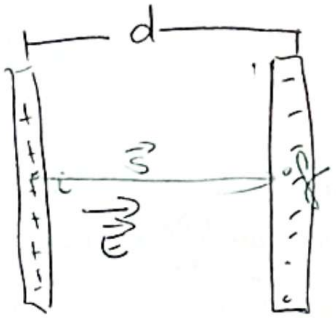
. Campo $\vec{E}$ elétrico.

$$\Phi_T = \Phi_{\text{lateral}} = \oint \vec{E} \cdot d\vec{A}$$

$$\frac{q_{env}}{\varepsilon_0} = \oint E \cdot dA \quad \Rightarrow \quad E = \frac{q_{env}}{\varepsilon_0 A} \quad \Rightarrow \quad E = \frac{\sigma}{\varepsilon_0}$$

. Potencial elétrico

$$V_f - V_i = -\int_i^f \vec{E} \cdot d\vec{s}$$



$$V_f - V_i = -\int_{S_i}^{S_f} \frac{\sigma}{\varepsilon_0} ds$$

$$V_- - V_+ = -\sigma (S_f - S_i)$$

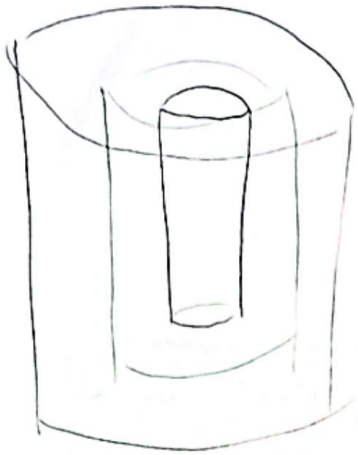
$$V_- - V_+ = -\frac{\sigma}{\varepsilon_0} d$$

negativo?

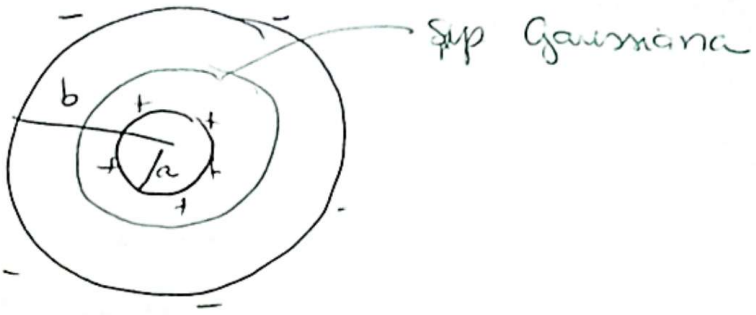
↳ faz sentido

Digitalizado com CamScanner

• Capacitor cilíndrico



De cima:



$$\frac{q_{env}}{\varepsilon_0} = \oint \vec{E}.d\vec{A} = \int_{cilindro} \vec{E}.d\vec{A}$$

$$\frac{q}{\varepsilon_0} = E.\underbrace{A}_{2\pi r.b} \Rightarrow$$

$$\sigma = \frac{q}{2\pi a.b}$$

$$\Rightarrow q = \sigma.2\pi ab$$

$$\frac{\sigma 2\pi ab}{\varepsilon_0} = E\,2\pi r.b$$

$$E = \frac{a\sigma}{r\varepsilon_0}$$

$$V_f - V_i = V_- - V_+ = -\int \vec{E}.d\vec{s}$$

$$= -\int \frac{a\sigma}{r\varepsilon_0} dr$$

$$= -\frac{a\sigma}{\varepsilon_0} \ln r \Big|_a^b$$

$$= -\frac{a\sigma}{\varepsilon_0} \ln(b/a)$$

Se

$$V_+ - V_- = -\int_-^+ \vec{E}.d\vec{s}$$

$$= +\int_-^+ E.ds$$

$$\int_b^a \frac{a\sigma}{r\varepsilon_0} dr$$

$$= \frac{a\sigma}{r\varepsilon_0} \ln\left(\frac{a}{b}\right)$$

$$\Downarrow$$

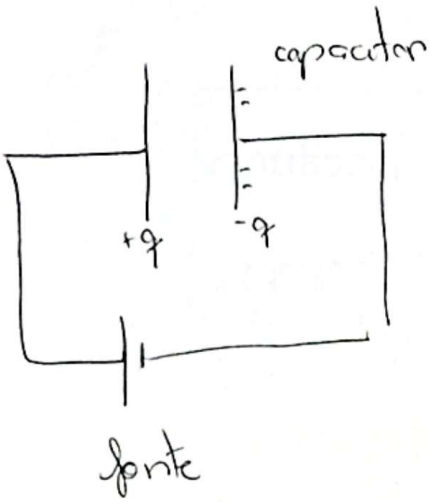
$$dr = -ds$$

* Fazer capacitor esférico

Digitalizado com CamScanner

Cap 25.b (início da matéria para a segunda prova)

Capacitores



$$C = \frac{q}{(V)} = \Delta V$$

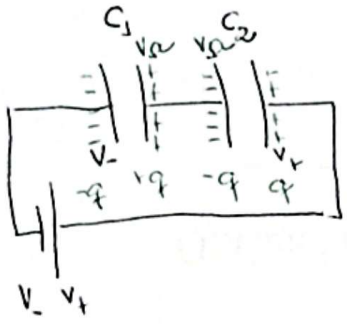
Vimos:

	ΔV	C
Placas Paralelas 	$E.d \Downarrow \frac{q}{A\varepsilon_0}$ $(\Delta V) = \frac{(q)d}{A\varepsilon_0}$	$\Rightarrow C = \frac{A\varepsilon_0}{d}$
Capacitor cilíndrico	$(\Delta V) = \frac{(q)}{2\pi\varepsilon_0 L} \ln\left(\frac{b}{a}\right)$	$\Rightarrow C = \frac{2\pi\varepsilon_0 L}{\ln(b/a)}$
Capacitor esférico	$(\Delta V) = \frac{(q)}{4\pi\varepsilon_0} \frac{(b-a)}{ab}$	$\Rightarrow C = \frac{4\pi\varepsilon_0 ab}{b-a}$

* observe que a capacitância não depende de q ou V; ela é uma característica intrínseca do material!

Digitalizado com CamScanner

1) Capacitores em série





ΔV

- acumulam a mesma quantidade de cargas

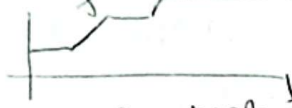
$$q_1 = q_2$$

- estão submetidos a ΔV diferentes

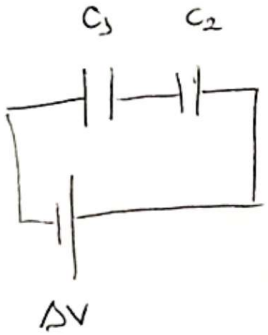
$$\Delta V_1 \neq \Delta V_2$$

$$\Delta V_1 + \Delta V_2 = \underbrace{\Delta V}_{V_+ - V_-}$$

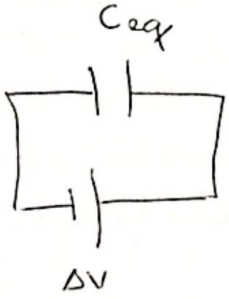
$$-\Delta V_2 + \Delta V_1 + \Delta V_2 = 0$$



- sistema equivalente:



$\equiv$



$$C_1 = \frac{q_1}{\Delta V_1}$$

$$C_2 = \frac{q_2}{\Delta V_2}$$

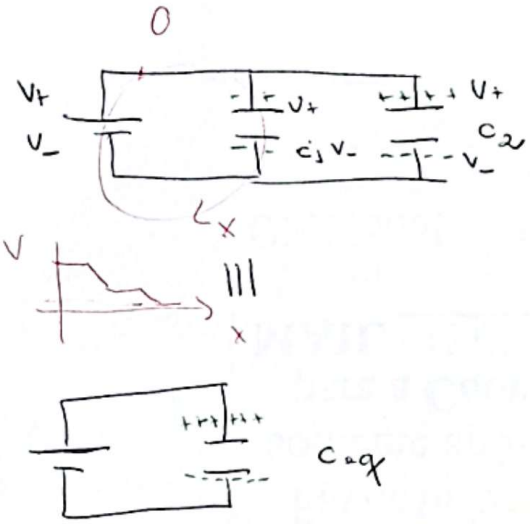
$$C_{eq} = \frac{q_{eq}}{\Delta V}$$

- $q_1 = q_2 = q_{eq}$
- $\Delta V_1 + \Delta V_2 = \Delta V$

$$\frac{q_1}{C_1} + \frac{q_2}{C_2} = \frac{q_{eq}}{C_{eq}} \Rightarrow \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{C_{eq}}$$

Digitalizado com CamScanner

2) Capacitores em paralelo



- $\Delta V_1 = \Delta V_2 = \Delta V_{eq}$ ✱
- $q_{eq} = q_1 + q_2$

$$C_1 = \frac{q_1}{\Delta V_1} \qquad C_2 = \frac{q_2}{\Delta V_2} \qquad C_{eq} = \frac{q_{eq}}{\Delta V}$$

$$C_{eq}\,\Delta V = C_1 \Delta V_1 + C_2 \Delta V_2$$ ✱

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

Digitalizado com CamScanner

Vimos:

$C = \frac{q}{V}$ $\quad [C] = \frac{C}{V} = F$

$C_0 = \frac{q_0}{\Delta V}$ $\quad C_K = \frac{q_K}{\Delta V}$

$C_K = \frac{q_K C_0}{q_0} \cdot \frac{1}{\Delta V}$

$C_K = K C_0$

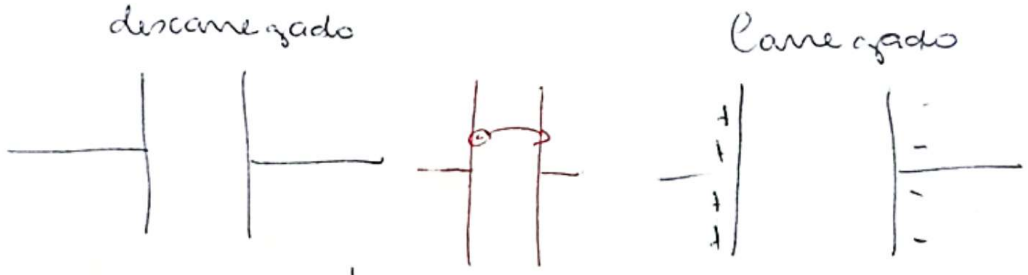
$C = K C_0$

↳ Capacitância no ar/vácuo

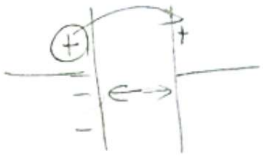
↳ constante dielétrica > 1

⇒ dielétrico aumenta a capacitância.

- Energia Armazenada em um capacitor



Energia equivale ao trabalho de tirar um elétron de um lado e passa para o outro lado



$W_i = +q_i \Delta V$ (ext)

$W_T = \sum_i W_i$

$\Delta V = V_- - V_+ < 0$

$\vec{F} = q\vec{E}$

$\vec{F}_{ext} = -q\vec{E}$

$\Delta V = ?$

$C = \frac{q}{\Delta V} \Rightarrow \Delta V = -\frac{q_{acumulada}}{C}$

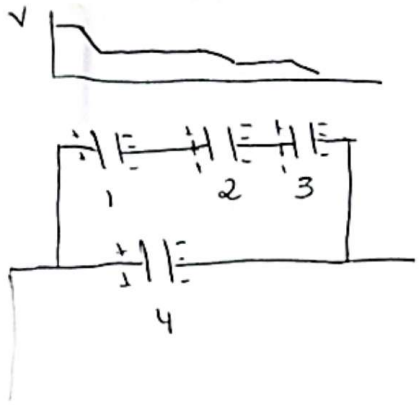
$dW = -(-dq + \frac{q_{acu}}{C})$ (com negativo)

$\Rightarrow W = \int_0^{q_f} \frac{q_{acu}}{C} dq \Rightarrow W = \int_0^{q} \frac{q}{C} dq$

$W = \frac{q^2}{2C} = U$ energia potencial

Digitalizado com CamScanner

16)



$C_3 = 0{,}8\,\mu F$

$q_1 = q_2 = q_3 = q$

$C = \dfrac{q}{\Delta V}$

$-(\Delta V_1 + \Delta V_2 + \Delta V_3) + \Delta V_4 = 0$

$C_3 = \dfrac{q_3}{\Delta V_3}$

$C_2 = \dfrac{q_2}{\Delta V_2}$

$= 0{,}8 \cdot \Delta V_3$

$q = 0{,}8\,\Delta V_3$

$C_2 = \dfrac{0{,}8\,\Delta V_3}{5} \Rightarrow C_2 = 0{,}16\,\Delta V_3$

$C_1 = \dfrac{0{,}8\,\Delta V_3}{2}$ $\quad C_1 = 0{,}4\,\Delta V_3$

$\Delta V_4 = 12$

$\Delta V_1 + \Delta V_2 + \Delta V_3 = \Delta V_4$

$2 + 5 + \Delta V_3 = 12$

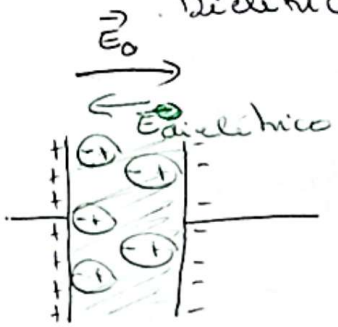
$\Rightarrow \underline{\Delta V_3 = 5V}$

Digitalizado com CamScanner

. Capacitores com dielétricos:

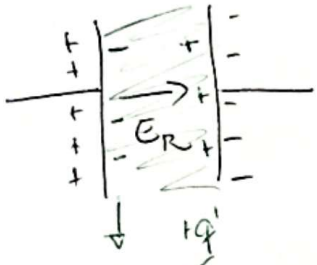
. Dielétrico: material isolante

→ Experimento: capacitor inicial. carregado dielétrico.



dielétrico

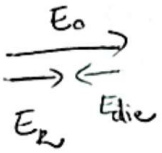
EQUIVALE À:



→ carga induzida.

$\vec{E}_0$ sem o dielétrico

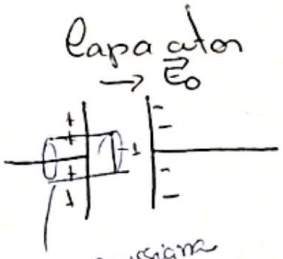
$\vec{E}_{die}$ gerado pelo dielétrico



$E_R = E_0 - E_{die}$

O campo elétrico é reduzido

Capacitor sem dielétrico

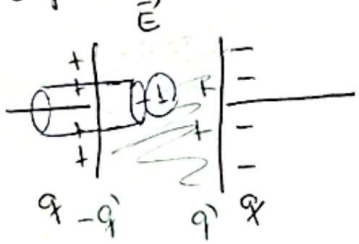


$$\Phi_{Tdal} = \Phi_S = \int \vec{E}.d\vec{A} = E.A$$

$$\Phi^{vácuo}_{Tdal} = E_0 A$$

$$\frac{q}{\varepsilon_0} = E_0 A$$

Capacitor com dielétrico



$$\Phi_{Tdal} = \Phi_S = \int \vec{E}_R.d\vec{A}$$

$$\frac{q-q'}{\varepsilon_0} = E_R.A$$

neste sistema equivalente, assumimos que q' está no vácuo

igualando $\varepsilon_0 A \Rightarrow \frac{q}{E_0} = \frac{q-q'}{E_R} \Rightarrow E_R = \frac{q-q'}{q} E_0$ (×1/K)

$E_R = \frac{1}{K} E_0$

$\Rightarrow E_0 = K E_R$

$K > 0$ pois $q > q'$

$K > 1$ pois $q' < q$

K é adimensional

$$K = \frac{q}{q-q'}$$

Digitalizado com CamScanner