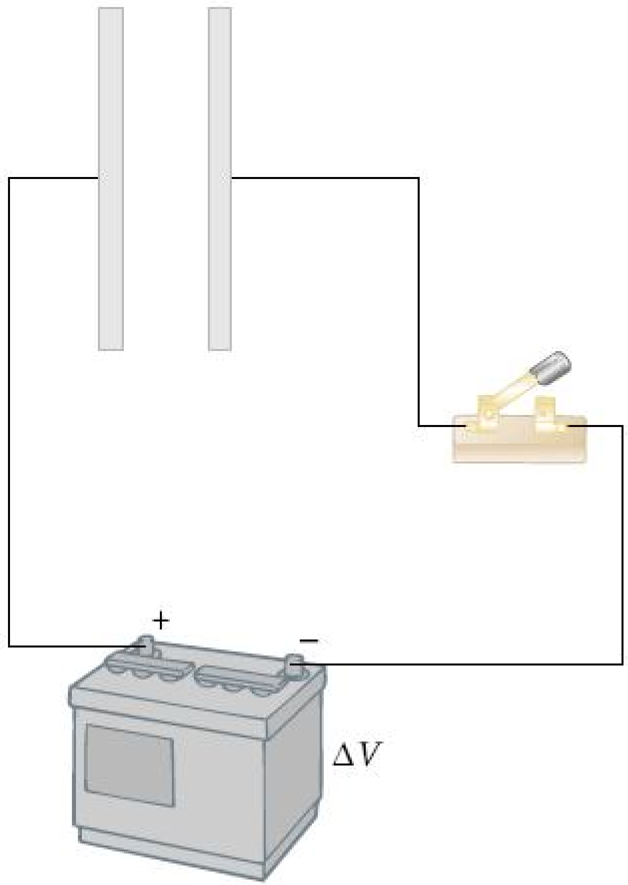
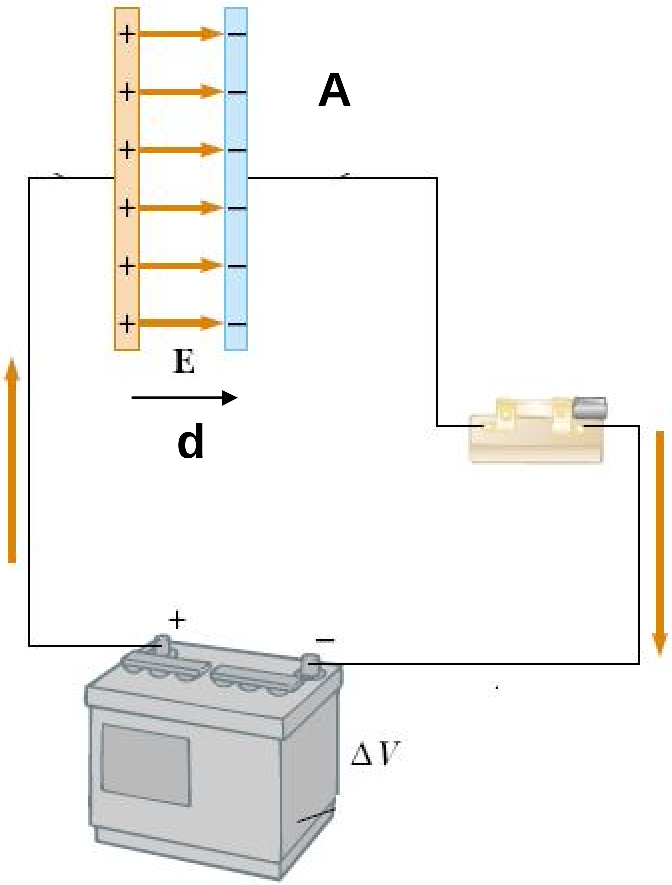
Dieléctricos

Bibliografía consultada

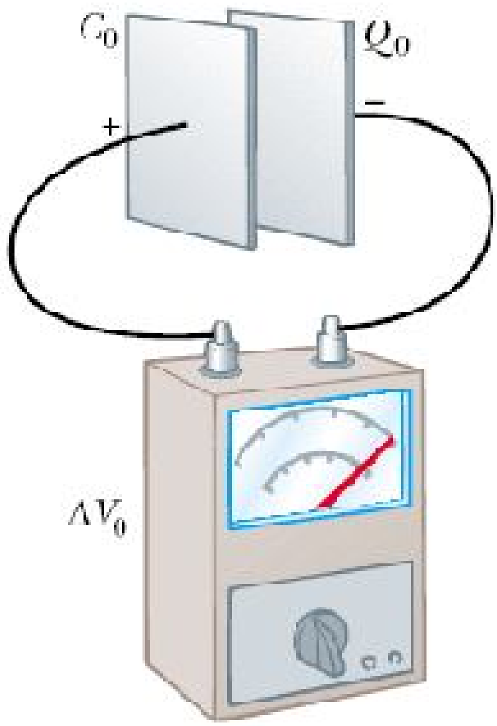
- **Sears- Zemasnky -Tomo II**
- **Fisica para Ciencia de la Ingeniería, Mckelvey**
- **Serway- Jewett --Tomo II**

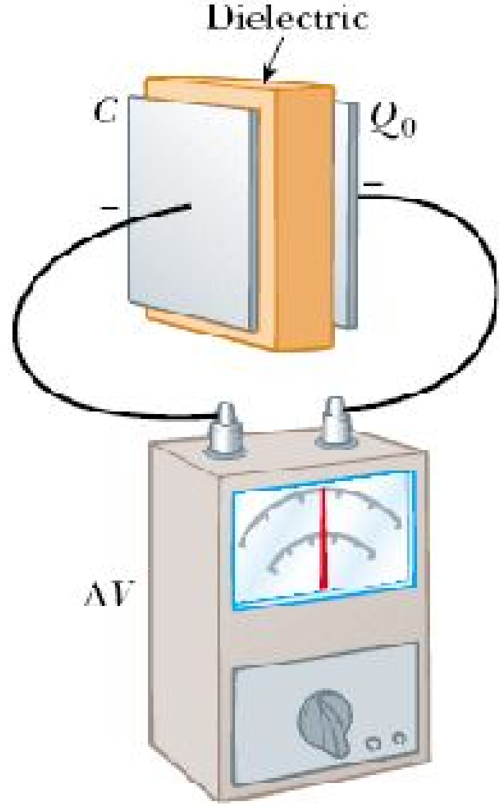
$$C = \frac{q}{\Delta V} = \frac{\sigma . A}{\Delta V} = \varepsilon_0 \frac{A}{d}$$





Faraday comprobó



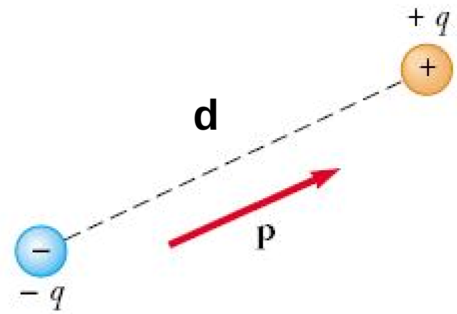


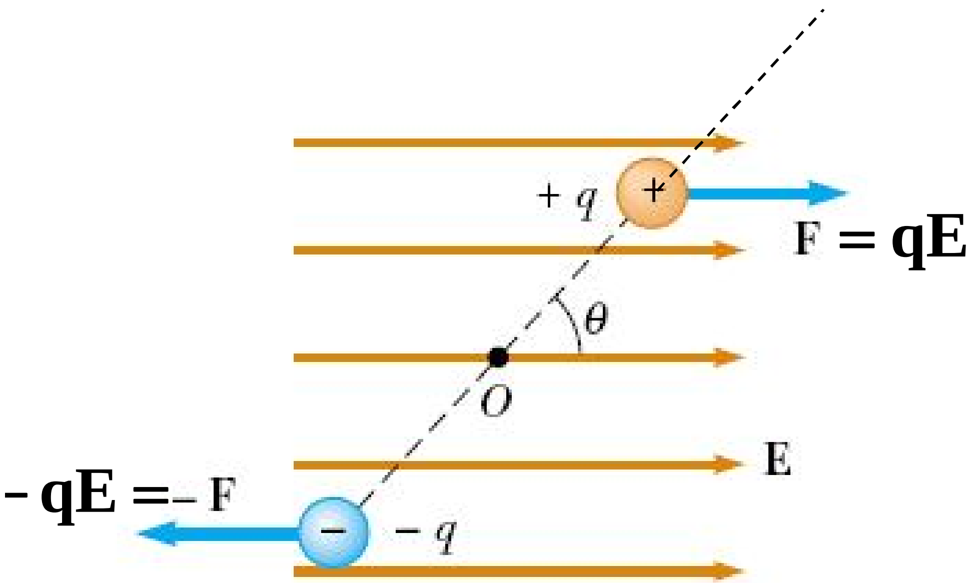
$$\Delta V = \frac{\Delta V_0}{\kappa}$$

$$C = \kappa C_0$$

DIELECTRICOS

INTERACCIÓN DIPOLO -CAMPO ELECTRICO





$$\sum F = 0$$

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\tau_+ = \frac{d}{2} F \,\text{sen}\theta = \frac{d}{2} qE \,\text{sen}\theta$$

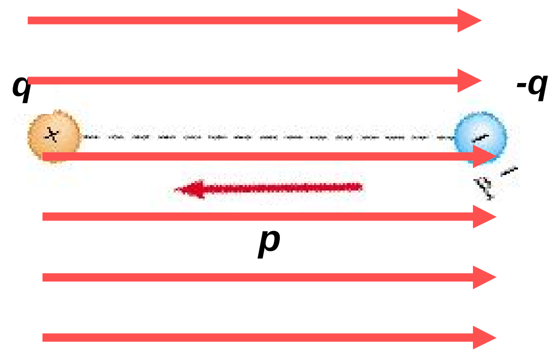
$$\tau_- = \frac{d}{2} F \,\text{sen}\theta = \frac{d}{2} qE \,\text{sen}\theta$$

$$\tau = d\, qE \,\text{sen}\theta = p\, E \,\text{sen}\theta$$

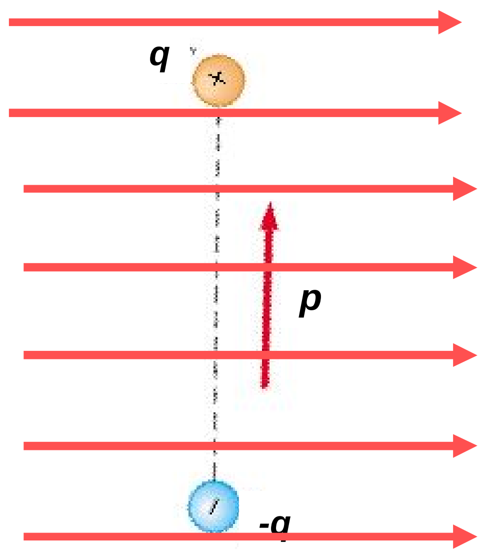
$$\vec{\tau} = \vec{p} \times \vec{E}$$

Eq. estable

$$\tau = 0$$



Eq. inestable



$$\tau \text{ es max.} = pE$$

El trabajo realizado para rotar el dipolo un ang. dθ

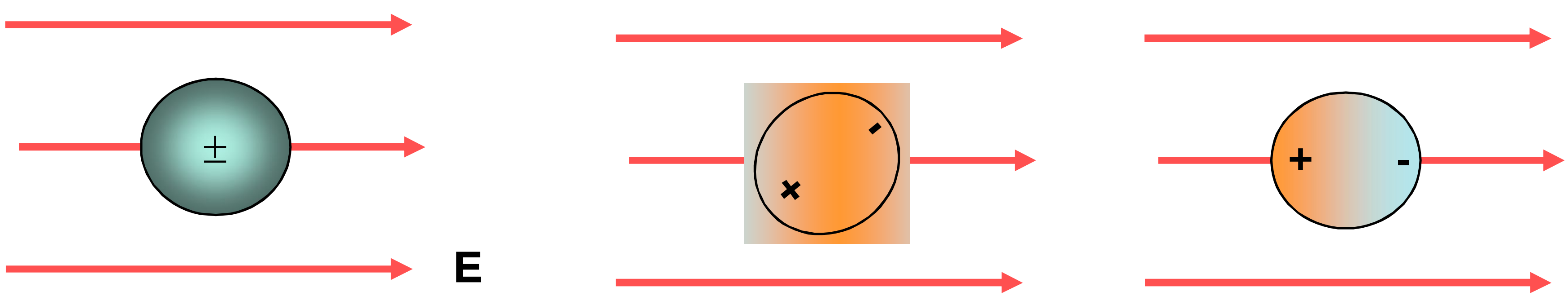
$$dW = \tau \, d\theta$$

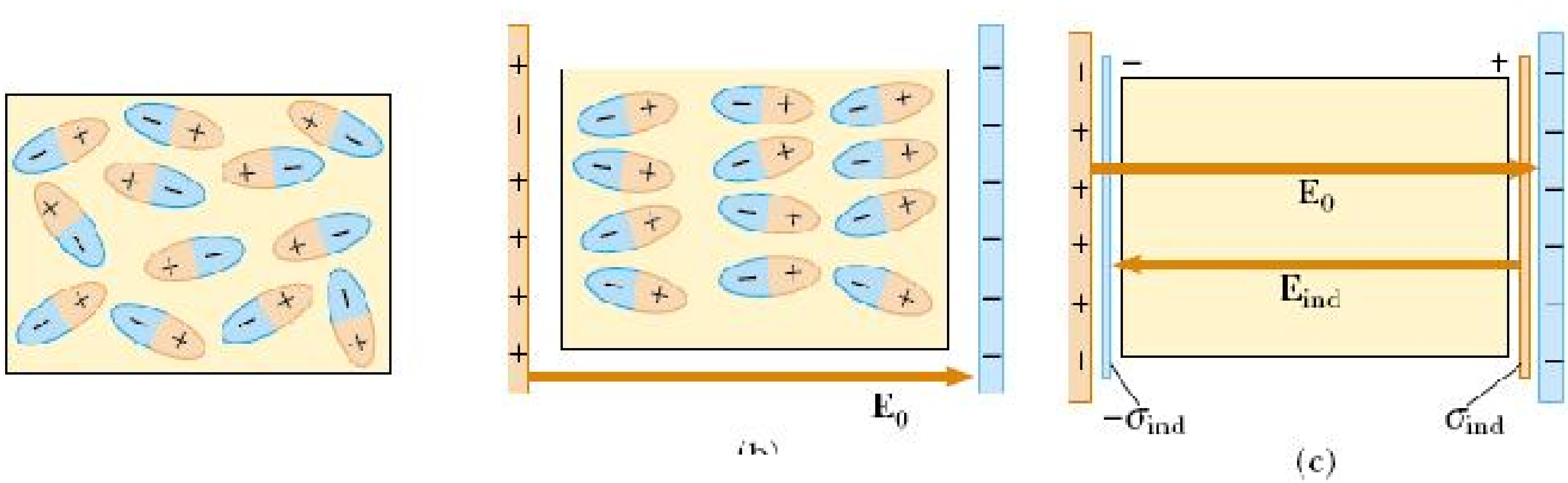
$$\Delta U = \int_{\theta_i}^{\theta_f} p\,E\,\mathrm{sen}\theta \, d\theta = p\,E\left(\cos\theta_i - \cos\theta_f\right)$$

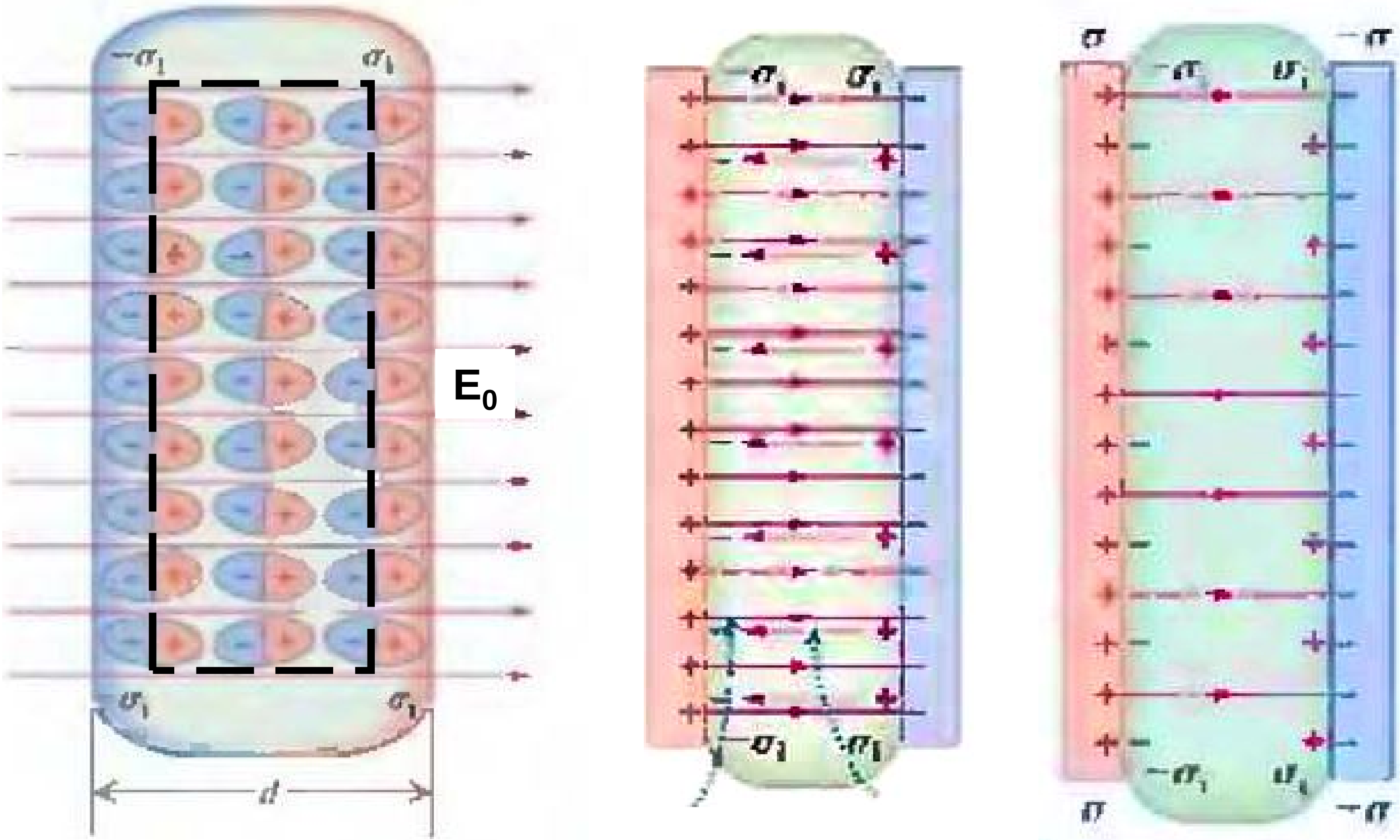
$$\theta_f = 0 \quad y \quad \theta_i = 90$$

$$U = -\mathbf{p}\cdot\mathbf{E}$$

Las moléculas { **Polares** / **No polares**

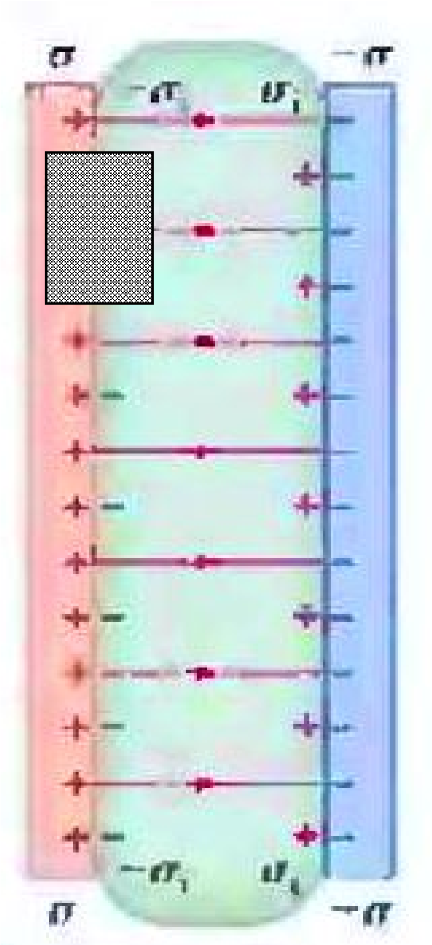


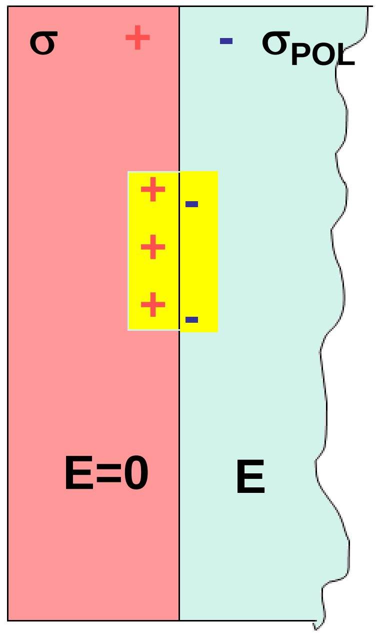



$-\sigma_1$
σ_1
E_0
d
σ
$-\sigma$

TEOREMA DE GAUSS

$$\phi_E = \oiint \vec{E}\,.d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$

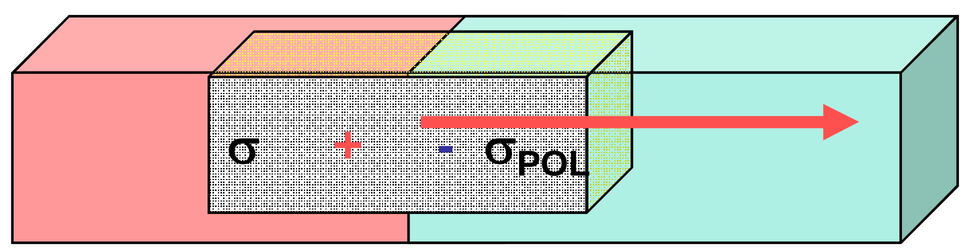


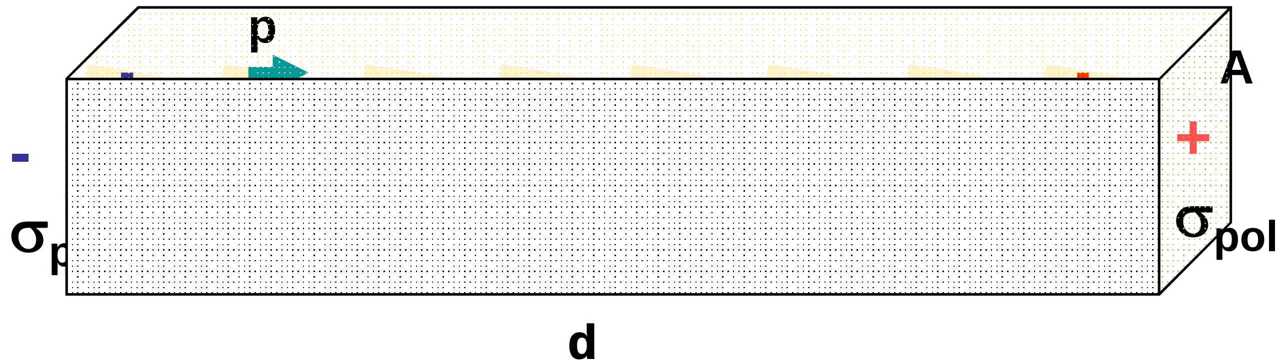


$$Q_{enc} = Q_L + Q_{pol}$$

$$Q_{enc} = \iint (\sigma_L + \sigma_{pol})\, ds$$

¿?





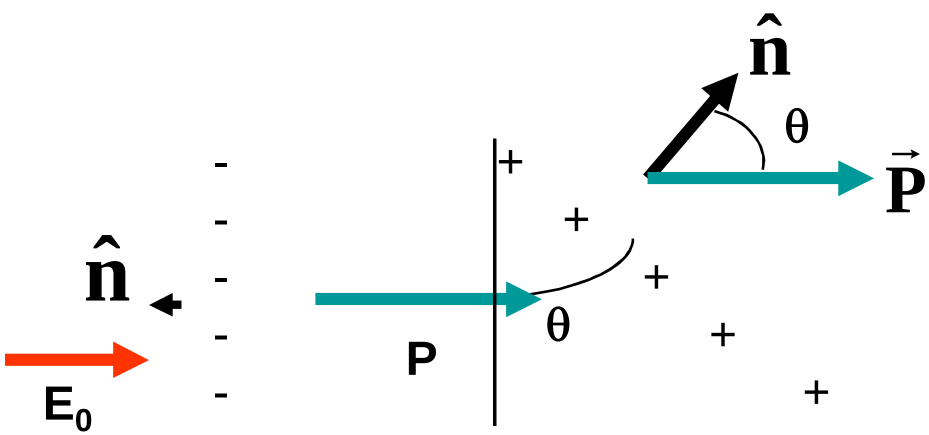
N moléculas con carga **q**

$$n = \frac{N}{Vol} = \frac{N}{A.d}$$

$$\Delta p = \sum_i p_i = q_{pol} d = \sigma_{pol} A\, d$$

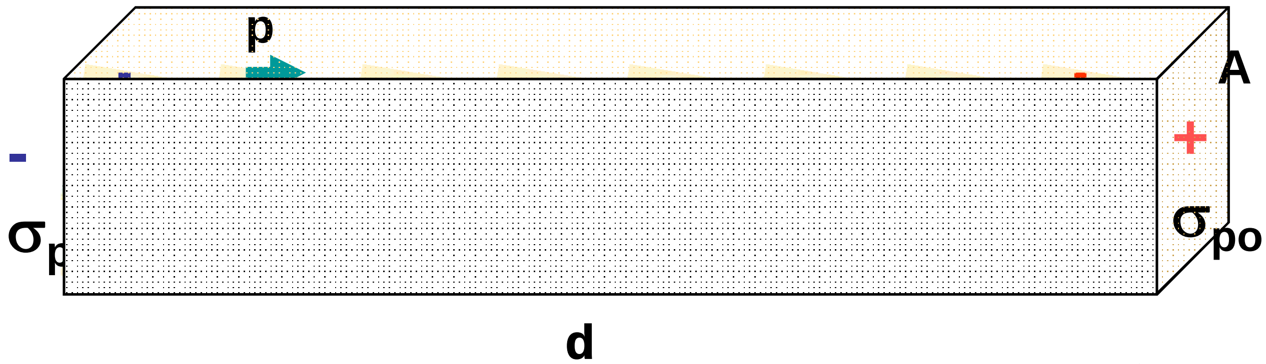
Vector Polarización

$$P = \lim_{Vol \to 0} \frac{\Delta p}{Vol} = \frac{\sigma_{pol} A\, d}{Vol} = \sigma_{pol}$$



$$\sigma_{pol} = \vec{P}.\hat{n}$$

Signo dado por la normal saliente



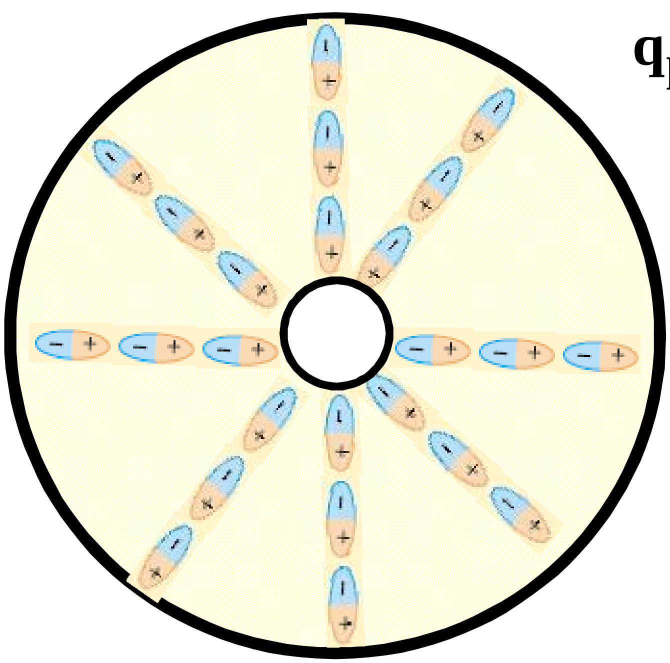
$$\sigma_{pol} = \vec{P}.\hat{n}$$

$$dq_{pol} = \sigma_{pol}\, dA = \vec{P}.\hat{n}\, dA = \vec{P}.d\vec{A}$$

$$q_{pol} = \iint \vec{P}.d\vec{A}$$

Si P=cte $\quad q_{pol\ sup} = \oiint \vec{P}.d\vec{A} = 0$

Si P≠cte

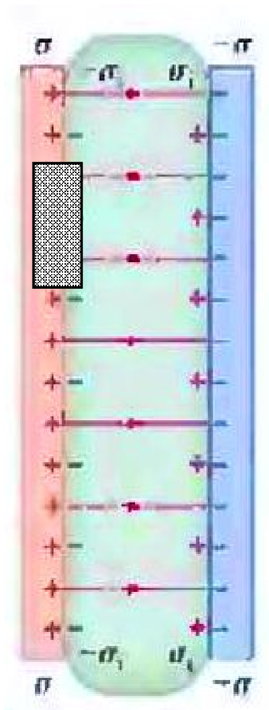


$$q_{pol\ sup} = \oiint \vec{P}.d\vec{A} \neq 0$$

Pero el dieléctrico estaba inicialmente descargado

$$q_{pol\ vol} = -q_{pol\ sup} = -\oiint \vec{P}.d\vec{A}$$

$$q_{pol\ vol} = \iiint \rho_{pol} = -\oiint \vec{P}.d\vec{A}$$



$$\oiint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0} = \frac{q_L}{\varepsilon_0} + \frac{q_{Pol}}{\varepsilon_0} = \frac{q_L}{\varepsilon_0} - \frac{1}{\varepsilon_0}\oiint \vec{P}\cdot d\vec{A}$$

$$\oiint \varepsilon_0\vec{E}\cdot d\vec{A} = q_L - \oiint \vec{P}\cdot d\vec{A}$$

$$\oiint (\underbrace{\varepsilon_0\vec{E} + \vec{P}}_{\vec{D}})\cdot d\vec{A} = q_L$$

$\vec{D}$ Vector Desplazamiento

$$\oiint \vec{D}\cdot d\vec{A} = q_L$$

$$\oiint \vec{E}\cdot d\vec{A} = \frac{q_T}{\varepsilon_0}$$

$$\oiint \vec{P}\cdot d\vec{A} = -q_{pol}$$

$$\oiint \vec{D}\cdot d\vec{A} = \iiint \rho_L\, dvol = \iiint \vec{\nabla}\cdot\vec{D}\, dvol$$

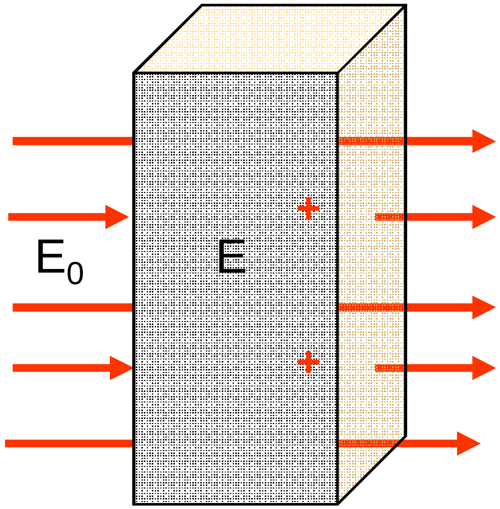
$$\oiint \vec{E}\cdot d\vec{A} = \frac{1}{\varepsilon_0}\iiint \rho_{total}\, dvol = \iiint \vec{\nabla}\cdot\vec{E}\, dvol$$

$$\oiint \vec{P}\cdot d\vec{A} = -\iiint \rho_{pol}\, dvol = \iiint \vec{\nabla}\cdot\vec{P}\, dvol$$

$$\vec{\nabla}\cdot\vec{D} = \rho_L$$

$$\vec{\nabla}\cdot\vec{E} = \frac{\rho_{Total}}{\varepsilon_0}$$

$$\vec{\nabla}\cdot\vec{P} = -\rho_{Pol}$$



$$E \leq E_0$$

$$\vec{P} = \chi\, \varepsilon_0\, \vec{E}$$

Susceptibilidad eléctrica

$\chi > 0$

Permitividad dieléctrica del vacío

$$[P] = \frac{C}{m^2} \qquad [E] = \frac{N}{C} \qquad [\varepsilon_0] = \frac{C^2}{N m^2}$$

$$\vec{D} = \varepsilon_0 \vec{E} + \vec{P}$$

$$\vec{D} = (\varepsilon_0 + \chi\, \varepsilon_0)\vec{E} = \underbrace{\underbrace{(1+\chi)}_{\varepsilon_r}\varepsilon_0}_{\varepsilon}\vec{E}$$

$$\vec{D} = \varepsilon_0 \varepsilon_r \vec{E} = \varepsilon \vec{E}$$

Medio	$\kappa = \varepsilon_r$	$E_{máximo}$ (V/m)
Aire	1,00059	$3\ 10^6$
Teflón	2,1	$60\ 10^6$
Mylar	3,2	$7\ 10^6$
Papel	3,7	$16\ 10^6$

RESUMEN

$$\vec{D} = \varepsilon_0 \vec{E} + \vec{P} \qquad \vec{D} = \varepsilon_r \varepsilon_0 \vec{E} \qquad \vec{P} = \chi\, \varepsilon_0\, \vec{E}$$

$$\oiint \vec{D}\,.d\vec{A} = q_L \qquad \vec{\nabla}\,.\vec{D} = \rho_L$$

$$\oint \vec{E}.d\vec{L} = 0 \qquad \vec{\nabla} \times \vec{E} = 0$$

$$\oiint \vec{E}\,.d\vec{A} = \frac{q_T}{\varepsilon_0} \qquad \vec{\nabla}\,.\vec{E} = \frac{\rho_{Total}}{\varepsilon_0}$$

$$\oiint \vec{P}.d\vec{A} = -q_{pol} \qquad \vec{\nabla}\,.\vec{P} = -\rho_{Pol}$$

$$\oiint \vec{D}\,.d\vec{A} = q_L$$

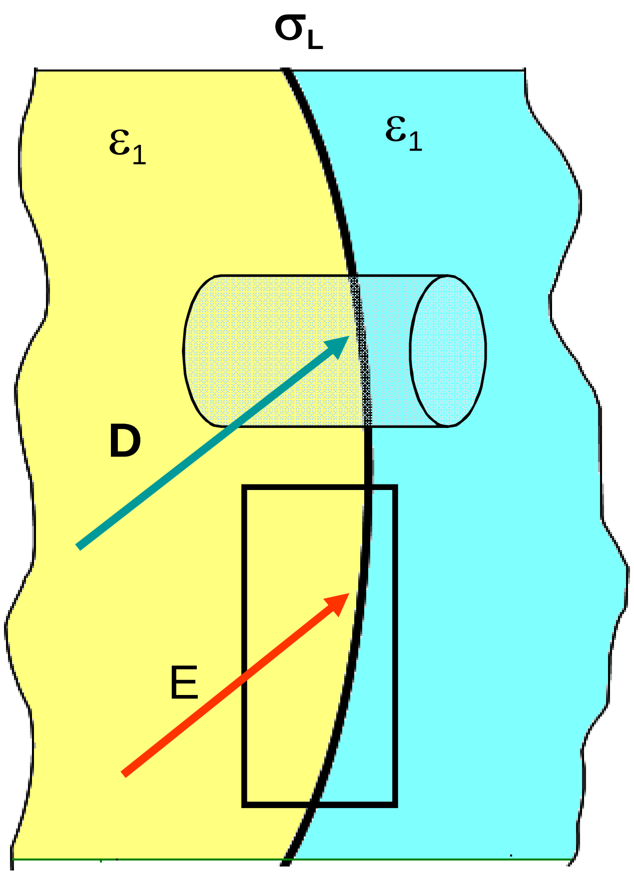
El flujo de D solo depende de las cargas libres
El flujo de D no depende del medio pero D si!!!!!

$$\oint \vec{D}.d\vec{L} = \oint \left(\varepsilon_0 \vec{E} + \vec{P}\right).d\vec{L} = \oint \vec{P}.d\vec{L}$$

$$\oint \vec{P}.d\vec{L} = 0 \Rightarrow \oint \vec{D}.d\vec{L} = 0 \quad \Rightarrow$$

D no depende del medio. Sólo de las cargas libres

CONDICIONES DE CONTORNO

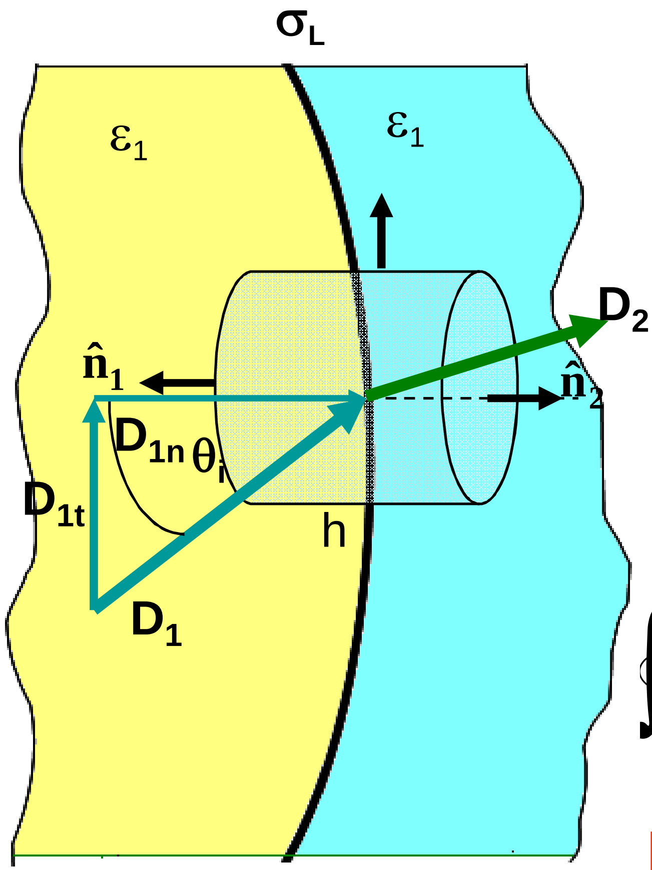


$$\vec{D} = \varepsilon_0 \vec{E} + \vec{P}$$

$$\vec{P} = \chi\, \varepsilon_0\, \vec{E}$$

$$\oiint \vec{D} \cdot d\vec{A} = q_L$$

$$\oint \vec{E} \cdot d\vec{L} = 0$$



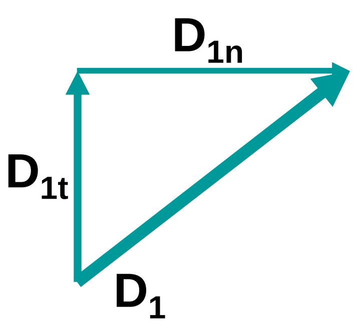
$$\oint\!\!\oint \vec{D}\,.d\vec{A} = q_L$$

$$\oint\!\!\oint \vec{D}.d\vec{A} = \iint_{\text{base}} \vec{D}.d\vec{A} + \iint_{\text{tapa}} \vec{D}.d\vec{A} + \iint_{\text{lateral}} \vec{D}.d\vec{A}$$

$$h \rightarrow 0$$

$$\oint\!\!\oint \vec{D}.d\vec{A} = \iint_{\text{base}} \vec{D}.\hat{n}_1 dA + \iint_{\text{tapa}} \vec{D}.\hat{n}_2 dA$$

$$\oint\!\!\oint \vec{D}.d\vec{A} = -\iint_{\text{base}} D_{1n} dA + \iint_{\text{tapa}} D_{2n} dA = \iint \sigma_L dA$$

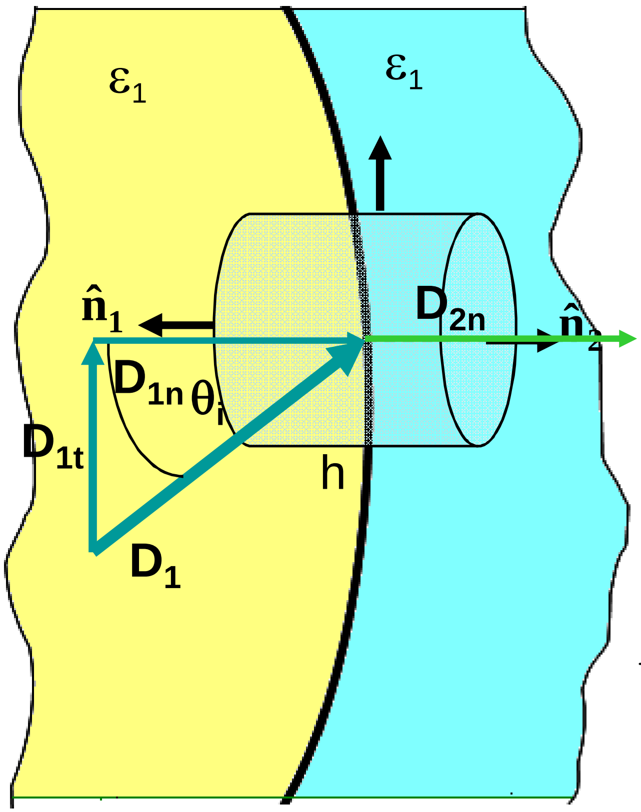


$$\boxed{D_{2n} - D_{1n} = \sigma_L}$$

$$\boxed{\varepsilon_2 E_{2n} - \varepsilon_1 E_{1n} = \sigma_L}$$

$$\boxed{\frac{\varepsilon_{r2}}{\chi_2} P_{2n} - \frac{\varepsilon_{r1}}{\chi_1} P_{1n} = \sigma_L}$$

$\sigma_L = 0$

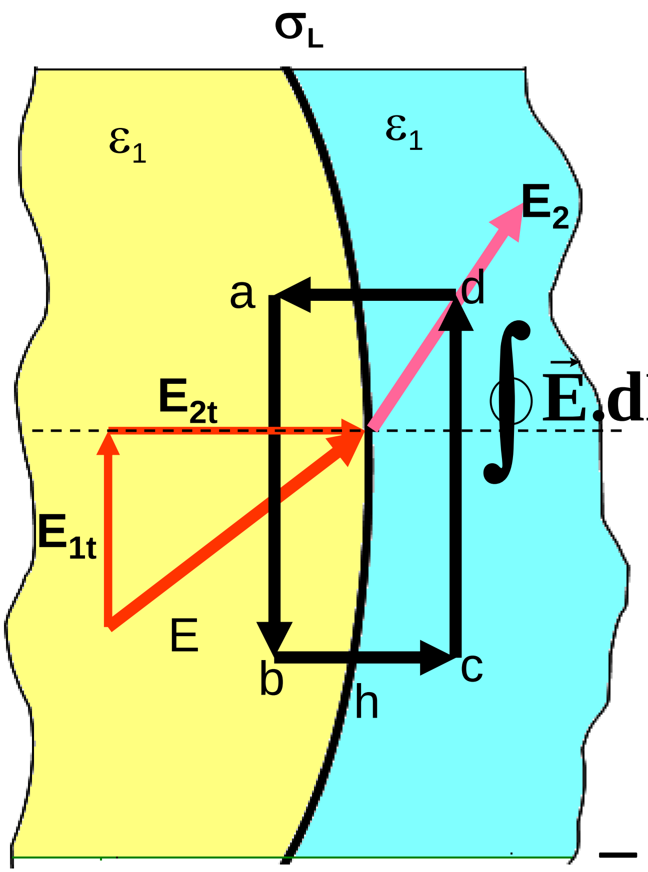


$$D_{2n} - D_{1n} = 0 \Rightarrow \boxed{D_{2n} = D_{1n}}$$

$$\varepsilon_2 E_{2n} - \varepsilon_1 E_{1n} = 0 \Rightarrow \boxed{E_{2n} = \frac{\varepsilon_1}{\varepsilon_2} E_{1n}}$$

$$\frac{\varepsilon_{r2}}{\chi_2} P_{2n} - \frac{\varepsilon_{r1}}{\chi_1} P_{1n} = 0 \Rightarrow \boxed{P_{2n} = \frac{\varepsilon_{r1}\,\chi_2}{\varepsilon_{r2}\,\chi_1} P_{1n}}$$

Se conserva la componente normal D



$$\oint \vec{E}.d\vec{L} = 0$$

$$\oint \vec{E}.d\vec{L} = \int_a^b \vec{E}.d\vec{L} + \int_b^c \vec{E}.d\vec{L} + \int_c^d \vec{E}.d\vec{L} + \int_d^a \vec{E}.d\vec{L} = 0$$

$$h \rightarrow 0$$

$$-\int_a^b E_{1t}\, dL + \int_c^d E_{2t}\, dL = 0$$

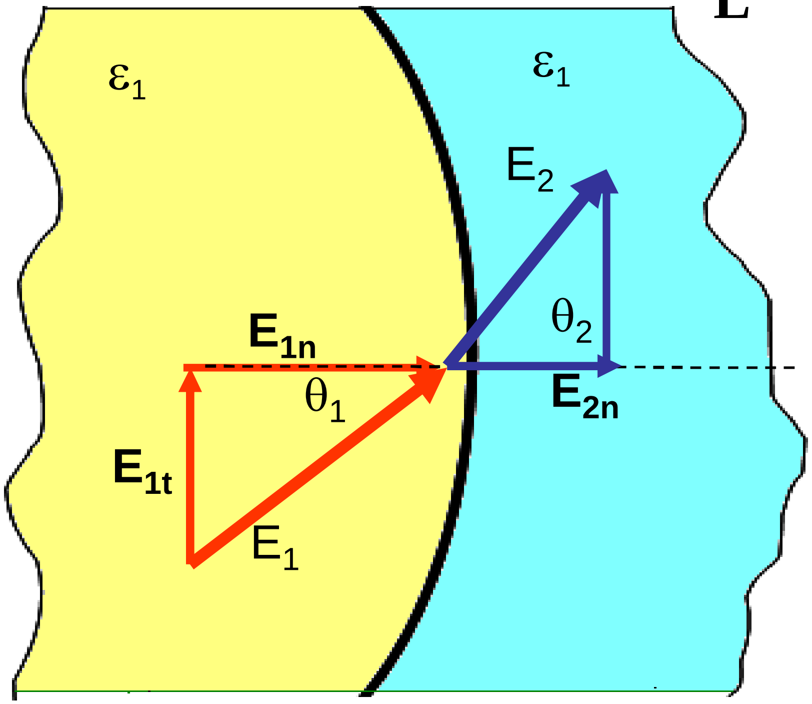
$$E_{1t} = E_{2t}$$

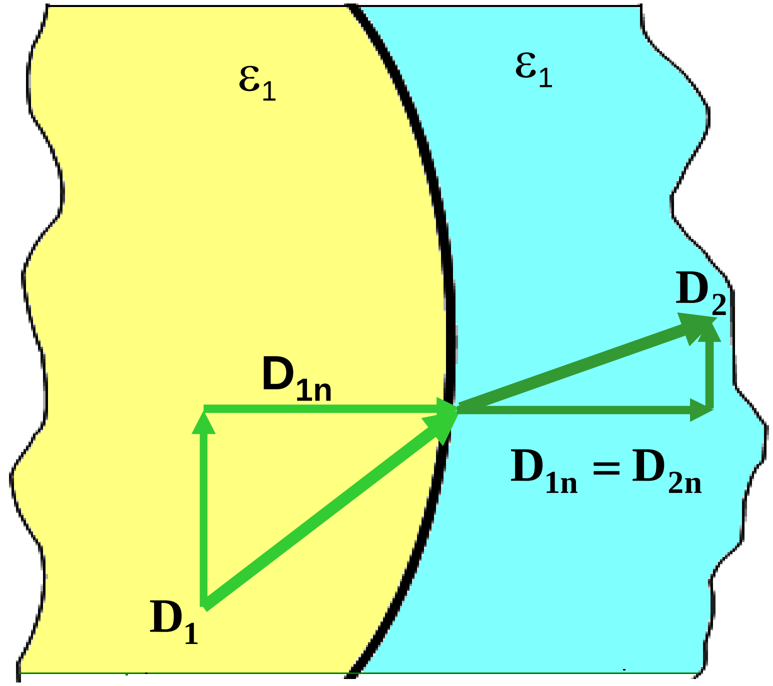
$$\frac{D_{1t}}{\varepsilon_{r1}} = \frac{D_{2t}}{\varepsilon_{r2}}$$

$$\frac{P_{1t}}{\chi_1} = \frac{P_{2t}}{\chi_2}$$

Se conserva la componente tangencial de **E**

$$\sigma_L = 0$$





$$E_{2n} = \frac{\varepsilon_1}{\varepsilon_2} E_{1n}$$

$$E_{1t} = E_{2t}$$

$$D_{2n} = D_{1n}$$

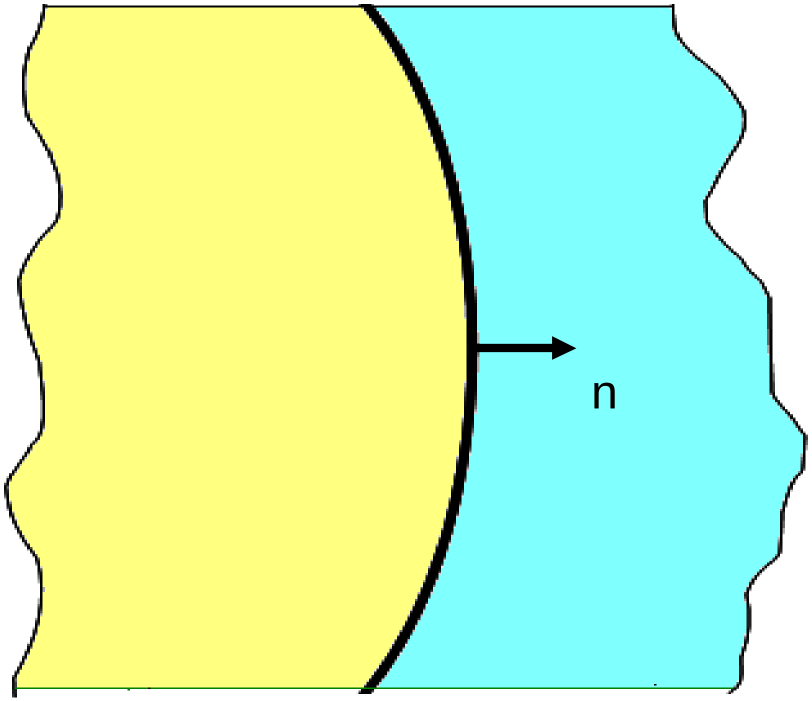
$$D_{2t} = D_{1t} \frac{\varepsilon_{r2}}{\varepsilon_{r1}}$$

D independiente del medio
Si $\mathbf{D_t}$ **es igual a ceo**

$$P_{2n} = \frac{\varepsilon_{r1}\chi_2}{\varepsilon_{r2}\chi_1} P_{1n}$$

$$P_{2t} = P_{1t} \frac{\chi_2}{\chi_1} =$$

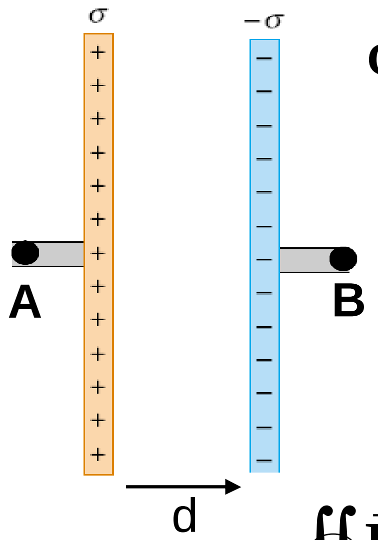
DENSIDAD DE CARGA SUPERFICIAL



$$\left(\vec{\mathbf{D}}_2 - \vec{\mathbf{D}}_1\right).\hat{\mathbf{n}} = \sigma_L$$

$$\left(\vec{\mathbf{P}}_2 - \vec{\mathbf{P}}_1\right).\hat{\mathbf{n}} = -\sigma_{Pol}$$

CAPACITOR DE PLACAS PLANO PARALELAS

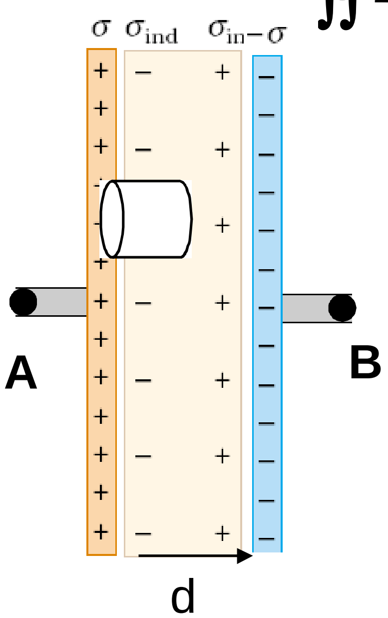


$$C_0 = \varepsilon_0 \frac{A}{d}$$

$$\vec{E} = \begin{cases} \dfrac{\sigma}{\varepsilon_0}\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\vec{D} = \begin{cases} \sigma\,\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\Delta V_0 = \frac{\sigma}{\varepsilon_0} d = \frac{Q}{\varepsilon_0\, A} d$$



$$\oiint \vec{D}\,.d\vec{A} = q_L \qquad \vec{D} = \begin{cases} \sigma\,\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

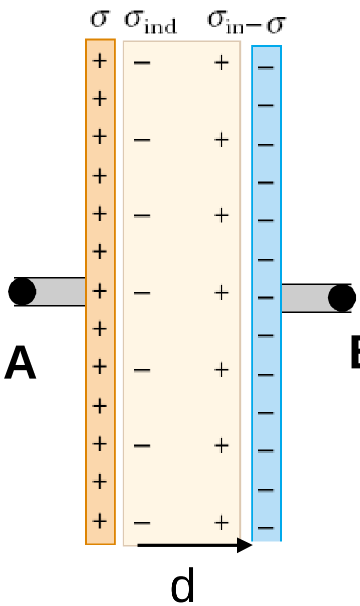
$$\vec{E} = \begin{cases} \dfrac{\sigma}{\varepsilon_0\,\varepsilon_r}\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\Delta V = V_A - V_B = -\int_d^0 \vec{E}.d\vec{l} = -\int_d^0 \frac{\sigma}{\varepsilon_0\,\varepsilon_r} dx = \frac{\sigma}{\varepsilon_0\,\varepsilon_r} d$$

$$\Delta V > \Delta V_0$$

$$\boxed{C = \frac{Q}{\Delta V} = \frac{\sigma.A}{\Delta V} = \varepsilon_0\,\varepsilon_r \frac{A}{d}}$$

$$C > C_0$$



$$\vec{D} = \begin{cases} \sigma\,\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\vec{E} = \begin{cases} \dfrac{\sigma}{\varepsilon_0\,\varepsilon_r}\,\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\vec{D} - \varepsilon_0 \vec{E} = \vec{P}$$

$$\vec{P} = \begin{cases} \sigma\left(1 - \dfrac{1}{\varepsilon_r}\right)\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

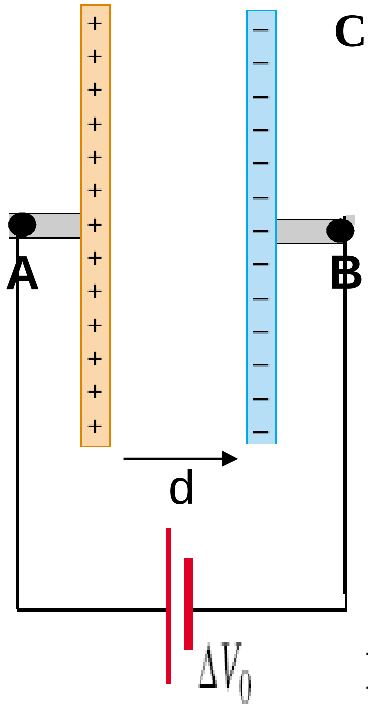
$$\left(\vec{P}_2 - \vec{P}_1\right).\hat{n} = -\sigma_{Pol}$$

$$\sigma\left(1 - \frac{1}{\varepsilon_r}\right) = -\sigma_{Pol-}$$

$$-\sigma\left(1 - \frac{1}{\varepsilon_r}\right) = -\sigma_{Pol+}$$

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{Q^2}{C_0\,\varepsilon_r} = \frac{U_0}{\varepsilon_r}$$

$$U < U_0$$



$$C_0 = \varepsilon_0 \frac{A}{d}$$

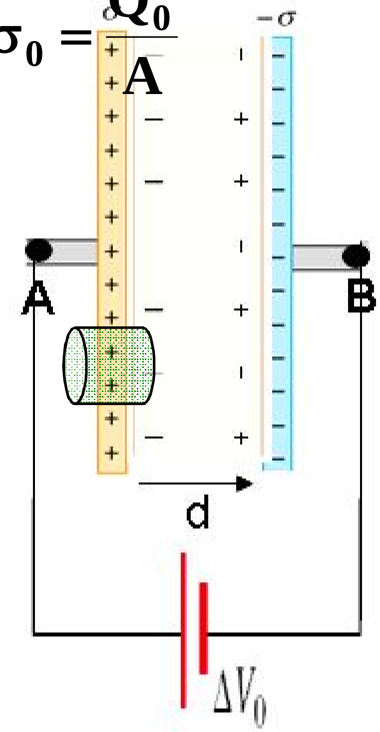
$$\vec{E} = \begin{cases} \dfrac{\sigma_0}{\varepsilon_0}\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\vec{D} = \begin{cases} \sigma_0 \, \hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\Delta V_0 = \frac{\sigma_0}{\varepsilon_0} d = \frac{Q_0}{\varepsilon_0 A} d$$

$$\frac{\Delta V_0 \, \varepsilon_0}{d} = \sigma_0 = \frac{Q_0}{A}$$

$$\oiint \vec{D} \cdot d\vec{A} = q_L$$



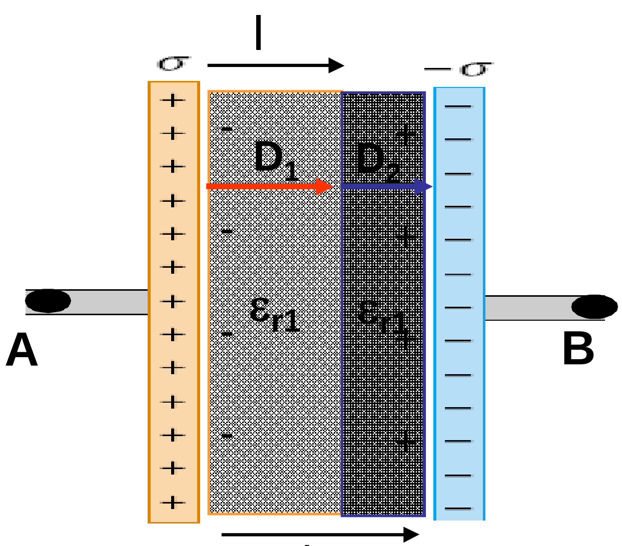
$$\vec{D} = \begin{cases} \sigma \, \hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\vec{E} = \begin{cases} \dfrac{\sigma}{\varepsilon_0 \, \varepsilon_r}\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\left.\begin{aligned} \Delta V_0 &= \frac{\sigma}{\varepsilon_0 \varepsilon_r} d = \frac{Q}{\varepsilon_0 \varepsilon_r A} d \\ \frac{\Delta V_0 \, \varepsilon_0 \, \varepsilon_r}{d} &= \sigma_0 = \frac{Q_0}{A} \end{aligned}\right\}$$

$$\sigma > \sigma_o$$

$$U = \frac{1}{2}\Delta^2 V C = U_0 \, \varepsilon_r \qquad U_0 < U$$



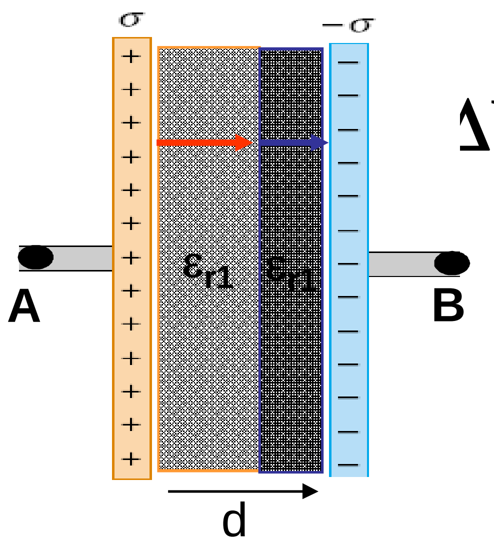
Sobre Sup. de separación **σ_L=0**

D es perpendicular a la superficie de separación
Entonces, D es independiente del medio $D_1=D_2$

$$\vec{\mathbf{D}} = \begin{cases} \sigma\,\hat{\mathbf{x}} & 0<x<d \\ 0 & \text{afuera} \end{cases}$$

$$\vec{\mathbf{E}} = \begin{cases} \dfrac{\sigma}{\varepsilon_0\,\varepsilon_{r1}}\hat{\mathbf{x}} & 0<x<l \\ \dfrac{\sigma}{\varepsilon_0\,\varepsilon_{r2}}\hat{\mathbf{x}} & l<x<d \\ 0 & \text{afuera} \end{cases}$$

$$\vec{\mathbf{P}} = \begin{cases} \sigma\left(1-\dfrac{1}{\varepsilon_{r1}}\right)\hat{\mathbf{x}} & 0<x<l \\ \sigma\left(1-\dfrac{1}{\varepsilon_{r2}}\right)\hat{\mathbf{x}} & l<x<d \\ 0 & \text{afuera} \end{cases}$$

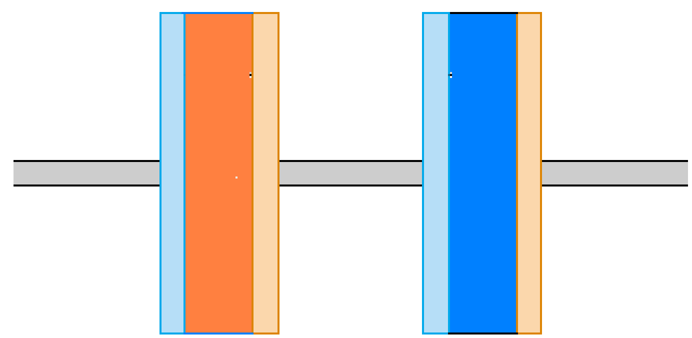


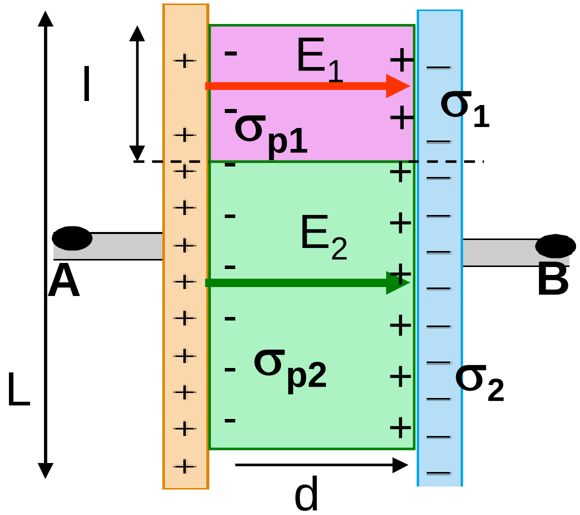
$$\Delta V = V_A - V_B = -\int_d^0 \vec{E}.d\vec{l} = -\int_d^l \vec{E}_2.d\vec{l} - \int_l^0 \vec{E}_1.d\vec{l}$$

$$= -\int_d^l \frac{\sigma}{\varepsilon_0 \varepsilon_{r2}} dx - \int_l^0 \frac{\sigma}{\varepsilon_0 \varepsilon_{r1}} dx =$$

$$= \frac{Q}{\varepsilon_0}\left(\frac{l}{\varepsilon_0 \varepsilon_{r1} A} + \frac{d-l}{\varepsilon_0 \varepsilon_{r2} A}\right)$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$





σ$_L$ permanece constante . Sobre Sup. de separación **σ$_L$=0,**

E es paralelo a la superficie de separación

Entonces, E es independiente del medio $E_2 = E_1$

$$D_1 \neq D_2$$

$$Q = Q_1 + Q_2 = \sigma_1 A_1 + \sigma_2 A_2 \qquad \sigma_2 = \frac{\sigma A - \sigma_1 A_1}{A_2}$$

$$E_1 = E_2 \Rightarrow \frac{\sigma_1}{\varepsilon_0\, \varepsilon_{r1}} = \frac{\sigma_2}{\varepsilon_0\, \varepsilon_{r2}} \qquad \sigma_2 = \sigma_1 \frac{\varepsilon_{r2}}{\varepsilon_{r1}}$$

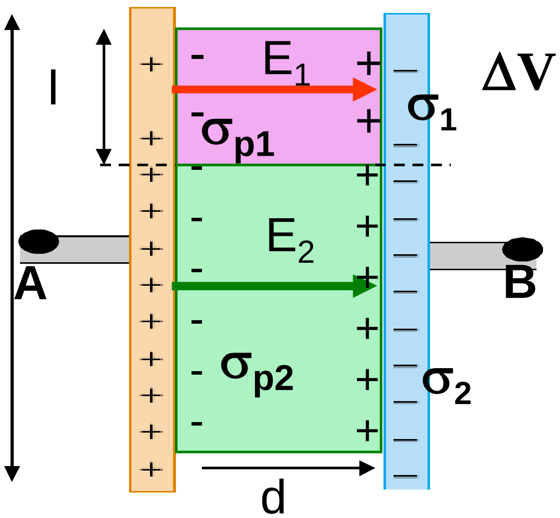
$$A_1 = l.a$$

$$A_2 = (L - l).a$$

$$\sigma_1 = \sigma \frac{A}{A_1 + A_2 \frac{\varepsilon_{r2}}{\varepsilon_{r1}}} \qquad \sigma_2 = \sigma \frac{A}{A_1 \frac{\varepsilon_{r1}}{\varepsilon_{r2}} + A_2}$$

$$\vec{E} = \begin{cases} \sigma \dfrac{1}{\varepsilon_0}\left(\dfrac{A}{A_1\varepsilon_{r1} + A_2\varepsilon_{r2}}\right)\hat{x} & 0 < x < d \\ 0 & \text{afuera} \end{cases}$$

$$\vec{D} = \begin{cases} \sigma \dfrac{A}{A_1 + A_2 \frac{\varepsilon_{r2}}{\varepsilon_{r1}}}\hat{x} & 0 < x < d, 0 < y < L - l, \\ \sigma \dfrac{A}{A_1 \frac{\varepsilon_{r1}}{\varepsilon_{r2}} + A_2} & 0 < x < d, L - l < y < L, \\ 0 & \text{afuera} \end{cases}$$



$$\Delta V = V_A - V_B = -\int_d^0 \vec{E}.d\vec{l} = -\int_d^0 \sigma \frac{1}{\varepsilon_0}\left(\frac{A}{A_1\varepsilon_{r1} + A_2\varepsilon_{r2}}\right) dl$$

$$= \sigma \frac{d}{\varepsilon_0}\left(\frac{A}{A_1\varepsilon_{r1} + A_2\varepsilon_{r2}}\right) = Q\left(\frac{d}{A_1\varepsilon_0\varepsilon_{r1}} + \frac{d}{A_2\varepsilon_0\varepsilon_{r2}}\right)$$

$$A_1 = l.a$$

$$A_2 = (L - l).a$$

$$\frac{Q}{\Delta V} = C = \frac{d}{A_1\varepsilon_0\varepsilon_{r1}} + \frac{d}{A_2\varepsilon_0\varepsilon_{r2}} = C_1 + C_2$$